U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

AMERICAN STANDARD SAFETY CODE FOR THE PROTECTION OF HEADS, EYES, AND RESPIRATORY ORGANS

NATIONAL BUREAU OF STANDARDS HANDBOOK H24
(Supersedes H2)

U. S. DEPARTMENT OF COMMERCE
DANIEL C. ROPER, Secretary

NATIONAL BUREAU OF STANDARDS
LYMAN J. BRIGGS, Director

National Bureau of Standards Handbook H24

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PREFACE

The first edition of this code was completed in the fall of 1920 and issued early in 1921. It was prepared with the cooperation of an advisory committee of 19 men who had been selected because of their interest in and knowledge of the subject and as being typical representatives of the interests most closely concerned. The code was developed from a set of safety standards originally prepared in cooperation with safety engineers of the War and Navy Departments, aided by experimental work at this Bureau, for use in Government establishments during the war. The second edition was issued in 1922 after revision by a Sectional Committee organized under the auspices and in compliance with the rules of procedure of the American Standards Association. The present edition of the code has been revised by a similar procedure.

The scope of the code has been enlarged from that of the previous edition by the inclusion of rules for protectors intended to prevent the worker from inhaling gases, dusts, fumes, etc., which might be injurious to the lungs. This field might be considered one distinct from that of protection to the eyes, but there are many processes where simultaneous protection of lungs and eyes is needed and some forms of equipment include in one protector both functions, as, for example, the protectors used in abrasive-blasting.

The arrangement of the code is such as first to present the general requirements, including a classification of the occupations which require protection. There then follow the detailed requirements for each group of occupations, operating rules, and finally the specifications for tests which must be met to insure that protectors will adequately fulfill their purpose. The last section of the code giving these specifications need only be considered by manufacturers and those who must determine whether protectors are suitable for the intended purpose; that is to say, by those agencies who will determine the approval of goggles or other devices as complying with the requirements of this code or, in the absence of such approval, by the purchasers of goggles who wish to determine for themselves the adequacy of the protectors offered for sale.

Following the code is a discussion of the rules which is intended to assist the reader in understanding the reasons for the rules and in interpreting the rules, and to give suggestions for the best means of carrying them out. It is hoped that those having occasion to apply the rules will contribute from their experience to amplify this part of the publication in future editions. The discussion of the rules has been prepared mainly by the staff of the National Bureau of Standards, and has not received the formal approval of the Sectional Committee nor of the American Standards Association.

The Bureau will also be glad to receive criticisms of the code requirements, and suggestions for its improvement, especially such as are based upon actual experience in the application of the rules. It is expected to issue revised editions from time to time with such changes as wider experience may dictate.

LYMAN J. BRIGGS, *Director*.

CONTENTS

AMERICAN STANDARD SAFETY CODE FOR THE PROTECTION OF HEADS, EYES, AND RESPIRATORY ORGANS

SECTION 1. GENERAL REQUIREMENTS

10. Scope, Application, and Compliance

(*a*) *Scope.*—The following rules apply to all industrial operations or processes which, by reason of the nature of the operation or process, present a sufficiently serious hazard to the head, face, neck, eyes, or respiratory organs of a worker as to be liable to injure them.

(1) Goggles are not required for machine work if the machine is furnished with guards which adequately protect the worker from the hazards otherwise involved in the operation or process. Respirators or masks need not be used if sufficient ventilation is provided to exhaust objectionable gases, dusts, mists, and fumes, so that they cannot affect the worker, or if the process is so inclosed that the atmosphere outside of the inclosure is not vitiated.

(2) No worker shall be continuously subjected without a protector to an atmosphere proved to be hazardous to health.

(3) It is recommended that no worker be continuously subjected without a protector to an atmosphere containing any form of mineral dust in quantity exceeding 50 million particles per cu ft (1,770 million per cu m) or 0.0044 grains per cu ft (10 mg per cu m) of a size less than 10 microns, as determined by the impinger method.

(*b*) *Application.*—Employers shall furnish protectors of a type suitable for the work to be performed, and the employee shall use such protectors when employed in processes or operations, or those of similar hazard, designated in rule 11 by the following letters: *A*, *B*, *D*, *E*, *G*, *H*, *I*, *J*, *K*, and *L*. Employers shall furnish protectors upon application of employees working in the processes or operations classified in groups *C* and *F*, rule 11.

(*c*) *Compliance.*—The method to be pursued to assure that protectors will be used which meet the specifications and tests prescribed by these rules, shall be determined by the proper administrative authority.

The word "shall," where used, signifies that the requirement is mandatory and "should" advisory.

11. Classification of Operations and Processes

The processes or operations in which it is necessary that the operator be given protection to the head, eyes, or respiratory organs, are divided into 12 groups, each of which requires a protector having distinctive features. The examples given for each group are illustrative only and are not intended to be complete lists of the operations or processes for which protection is necessary. These groups are as follows:

GROUP A.—Processes where protection from relatively large flying objects is required.

Examples of these processes are chipping, calking, some riveting operations, and sledging in quarries.

GROUP B.—Processes where protection from dust and small flying particles is required.

Examples are scaling and grinding of metals, stone dressing where quartz is not involved, and some woodworking operations.

GROUP C.—Operations where protection from dust and wind is required.

Examples are automobile driving, airplane piloting in open cockpits, and electric spot and butt welding where there is no exposure to radiant energy.

GROUP D.—Processes where protection from splashing metal is required.

Examples are babbitting, pouring of lead joints for cast-iron pipes, casting of hot metal, and dipping in hot-metal baths.

GROUP E.—Processes where protection to the eyes from gases, fumes, and liquids is required.

Examples are handling of acids and caustics, dipping in galvanizing tanks and some japanning operations.

GROUP F.—Operations where protection is required from reflected light or glare.

Examples are long exposure to snow-covered ground, exposure to reflected sunlight from roofs, roadbeds, etc.

GROUP G.—Processes where protection from injurious radiant energy with a moderate reduction in intensity of the visible radiant energy is required.

Examples are oxyacetylene and oxyhydrogen welding and cutting; tending electric arc furnaces; open-hearth, Bessemer, and crucible steel making; furnace work; electric-resistance welding; brazing; and testing of lamps, involving exposure to excessive brightness.

GROUP H.—Processes where protection from injurious radiant energy with a large reduction of the visible radiant energy is required.

Examples are electric-arc welding and cutting, irradiation with ultraviolet light, hydrogen welding.

GROUP I.—Processes where protection from dust, smoke, mists, or fumes is necessary to prevent solid or liquid particles from entering the respiratory tract.

Examples are lead-oxide manufacture and handling, tunneling, granite cutting, quartz grinding, sanding woodwork, spray coating (lead or siliceous materials).

GROUP J.—Abrasive blasting.

GROUP K.—Processes where it is necessary to prevent gases or vapors from entering the respiratory tract because of poisonous or chemical action involved.

Examples are cleaning petroleum storage tanks, spray painting with poisonous volatile materials, exposure to carbon monoxide, exposure to ammonia or mercury vapor.

GROUP L.—Operations where protection to the head is required from falling objects.

Examples are some conditions of building construction, mining, shipbuilding, and coal trimming on barges.

Caps or nets covering the hair are recommended for operators in shops where there is moving machinery or power-transmission apparatus in which their hair might become entangled.

12. Definitions.

Protector.—A protector is a device which is placed in front of or over the eyes, face, or head to afford protection from the hazards in industrial processes or from the natural elements.

Goggles.—Goggles are an optical device worn in front of the eyes, whose predominant function is protection to the eyes only.

Face Mask.—A face mask is a device worn before the eyes and a portion or all of the face, whose predominant function is protection to the eyes and face.

Helmet.—A helmet is a rigid device worn by the operator, which shields the eyes, face, neck, and a portion or all of the other parts of the head and is held in place by suitable means.

Hood.—A hood is a nonrigid device which completely covers the head, neck, and portions of the shoulders so as to exclude dust and flying particles.

Shield.—A shield is a device to be held in the hand, or supported without the aid of the operator, whose predominant function is protection to the eyes and face.

Gas Mask.—A gas mask is a device to be worn on the face, and so arranged that the inhaled air is drawn entirely through a canister which chemically cleans it. A mechanical filter may be included and goggles may be mounted on the mask.

Supplied-Air Respirator.—A supplied-air respirator is a device designed to supply the wearer with air suitable to breathe while surrounded by a contaminated atmosphere, and to prevent the latter from being inhaled.

Hose Mask.—A hose mask is a supplied-air respirator having a tight-fitting facepiece to which is attached a hose through which air may be forced by a blower, and through which the wearer can inhale whether the blower is operating or not.

Air-Line Respirator.—An air-line respirator is a supplied-air respirator designed to be connected by a hose to a supply of fresh air under positive pressure sufficient to maintain a continuous flow into the facepiece.

Filter Respirator.—A filter respirator is a device designed for the wearer to inhale the surrounding atmosphere after it has passed through a filtering medium to remove the impurities. The filtering medium may chemically absorb or mechanically obstruct the impurities.

Cartridge-Type Respirator.—A cartridge-type respirator is a filter respirator whose filtering equipment is carried in one or more cartridges mounted on the facepiece. Such a respirator may be a mechanical-filter respirator, a chemical-filter respirator, or a combination of both.

13. Classification of Protectors.

The face mask, helmet, shield, respirator, gas mask, hose mask, and hood types of protectors are referred to in these rules by name.

For the purpose of clearly defining the application of the styles of goggles to the processes given in rule 11, and for clearly differentiating between the tests which are to be applied to them, goggles shall be considered as falling in two main classes, namely, rigid-front goggles and goggles with flexibly connected lens containers. Included in the class of goggles with rigid fronts are the nonadjustable rigid-bridge type and the adjustable metallic-bridge type of goggles, in both of which the bridge is rigidly fastened to the lens container. The flexibly connected type of goggles consists of those which have a flexible connecting link between the lens containers.

Goggles shall be designated according to styles as follows:

Style 1.—Goggles having rigid nonadjustable bridge (or adjustable metallic bridge) without side shields.

Style 2.—Goggles having rigid nonadjustable bridge (or adjustable metallic bridge) with side shields.

Style 3.—Goggles having flexibly connected lens containers shaped to conform to the configuration of the face.

14. Lenses for Persons Having Defective Vision.

Employees whose vision requires the use of corrective lenses in spectacles, and who are required by these rules to wear protective goggles, shall be provided with goggles of one of the following types:

(1) Goggles whose protective lenses provide the proper optical correction and withstand the drop test specified in

rule 153 (*a*). Such lenses are exempted from the requirements for parallelism of surfaces in rule 16 (*a*).

(2) Goggles which can be worn over corrective spectacles without disturbing the adjustment of the spectacles.

(3) Goggles which incorporate corrective lenses mounted inside the protective lenses.

15. Replacement of Lenses.

Protectors, the lenses of which may be replaced, shall be so designed that this may be accomplished without the use of tools of special character and design.

Lenses, or windows, and lens containers should be substantially uniform as to dimensions so as to facilitate the replacing and interchanging of lenses. The employer shall be responsible for the proper replacement of lenses upon application of an employee.

16. General Requirements for Glass.

(*a*) *All Glass.*—Glass for lenses and windows of protectors shall be hard, substantially free from striae, air bubbles, waves, and other flaws. Except when the lens is ground to provide proper optical correction for defective vision, the front and rear surfaces of lenses and windows shall be smooth and parallel within the following limits:

Windows and cover glasses for same, 35 min. of arc (½ prism diopter).

Lenses and cover glasses for lenses, 9 min. of arc (⅛ prism diopter).

The glass shall not be negative in refractive power in any meridian, shall not have a positive refractive power in any meridian greater than 0.12 diopter, and shall not have a greater difference in refractive power between any two meridians than 0.06 diopter.

(*b*) *Goggle Lenses.*—All lenses shall have dimensions not less than 1.5 in. (38 mm) in the vertical direction and 1.75 in. (44.5 mm) in one horizontal direction. It is recommended that circular lenses not involving optical correction be of a uniform diameter of 1.97 in. (50 mm).

17. Identification of Protectors.

Each device shall be marked distinctly to facilitate identification.

SECTION 2. PROTECTORS FOR CHIPPING, RIVETING, CALKING, ETC.

GROUP A

20. Styles Permitted.

Goggles of styles 2 and 3, face masks, and helmets are the only permissible styles, except that for work in locations where side vision is important, as in quarries, goggles of style 1 are permissible, provided the lenses are at least 1.97 in. (50 mm) in diameter, and meet the drop test specified in rule 153 (*b*).

21. Specifications and Tests for Lenses.

(*a*) *Specifications.*—Lenses shall transmit not less than 70 percent of the visible light from the standard source specified in rule 154 (*a*). (See also rule 16.)

Each lens shall bear some permanent distinctive marking by which its source may be readily identified.

(*b*) *Test.*—Samples of lenses for use in operations included in Group A shall be submitted to the tests described in rule 153 to determine their quality.

22. Goggles of Style 2.

(*a*) *Frames.*—Frames shall be made of a material that will withstand sterilization and will not readily corrode and will not discolor the skin. Frames shall have a smooth finish.

(*b*) *Lens Containers.*—Containers shall be suitable for holding lenses of dimensions specified in rule 16.

(*c*) *Side Shields.*—If goggles are provided with side shields, such shields shall be made of metal, leather, or other material of suitable durability. No quick-burning material shall be used. The material shall be sufficiently pliable to permit adjusting the shield to the contour of the face. The edges coming in contact with the face shall be finished in a manner to prevent irritating or cutting the skin. If the side shields are of metal, they shall be of wire mesh or of perforated sheet having openings not larger than 0.0394 in. (1 mm). Adequate ventilation shall be provided.

The construction of the goggles shall be such as to permit the folding of the temples so that they may be stored in a case or container.

(*d*) *Temples.*—Temples shall be made of a material which can be sterilized without deterioration and will not readily corrode and will not discolor the skin. Ear hooks for temples shall be flexible, properly formed to fit the ear, and so finished or covered as not to cut or irritate the skin. No quick-burning material shall be used. If a covering be used, it shall extend for half the length of the temple and be of a material which will not readily deteriorate in service. The screw or rivet which fastens the temple to the frame shall not also be used to hold the lens in the container.

(*e*) *Short Temples.*—Short temples may be substituted for full-length temples. They shall be made of a material that will not readily corrode and will not discolor the skin. They shall be attached to the frame in the same manner as and be interchangeable with the full temples. A head band shall be fastened to the outer ends of the short temples and shall be adjustable as to length and easily replaceable.

(*f*) *Headband or Headgear.*—In lieu of full temples or short temples, a headband or headgear of any suitable material and design may be supplied that will properly retain the goggles in position and afford comfort and protection to the wearer. Such headgear shall be adjustable as to size or shall be supplied in properly assorted sizes.

(*g*) *Connection between Lens Containers.*—Nosepieces, bridges, or connecting links between lens containers shall have the portions that come in contact with the skin of a material that will not readily corrode and will not discolor the skin. The construction shall be substantial and the nosepiece, bridge, or connecting link shall be securely fastened to the lens containers. If the weight of the goggle is borne by the bridge or nosepiece resting on the crest or sides of the nose of the wearer, these portions of the goggles shall have broad comfortable surfaces. The nosepiece, bridge, or connecting link shall be so constructed as to be readily adjustable, or the goggle shall be furnished in assorted sizes.

23. **Goggles with Flexibly Connected Lens Containers, Style 3.**

(*a*) *Eyecups.*—Eyecups shall be made of rigid, noninflammable material that will not readily corrode and will not discolor the skin and can be sterilized without deterioration. They shall be shaped to conform to the configuration of the face and shall have edges which will not cut the face. Proper ventilation shall be provided and the goggles shall be fitted with a headband or headgear of cloth, leather, or other suitable material, which will retain them in their proper position with reasonable comfort.

(*b*) *Lens Containers.*—Containers shall be suitable for holding lenses of dimensions specified in rule 16 (*b*). They should be designed to permit easy replacement of lenses.

24. **Test for Frames.**

The frames of goggles of style 2, having either adjustable or rigid bridges, used in processes included in group *A*, shall withstand the tests prescribed in rule 151 (*c*) and (*d*). The frames of protectors having rigid bridges used in processes included in group *A* shall also withstand the tests prescribed in rule 151 (*a*) and (*b*). The frames of goggles of style 3, if used in operations included in group *A*, shall withstand the tests prescribed in rule 151 (*c*).

All goggles used in processes included in group *A* shall withstand the corrosion test prescribed in rule 152, if the metal comes in contact with the skin. When padding is used to prevent such contact this test may be omitted.

If face masks or helmets are used, the lens containers shall be of such strength as to withstand the equivalent of the strength test prescribed in rule 151 (*c*).

SECTION 3. PROTECTORS FOR SCALING, GRINDING, ETC.

GROUP B

30. **Styles.**

Goggles of styles 1, 2, and 3 are permissible styles. They need not comply with any strength tests.

31. Specifications for Lenses.

Lenses shall transmit not less than 70 percent of the visible light from the standard source specified in rule 154 (*a*). (See also rule 16.)

32. Goggle Frames.

(*a*) *Styles 1 and 2.*—Frames of goggles of styles 1 and 2 for this class of service shall comply with rule 22 (except that the requirements of 22 (*c*) for side shields do not apply to goggles of style 1).

(*b*) *Eyecup Goggles.*—Eyecup goggles shall conform to the requirements of rule 23.

SECTION 4. PROTECTORS FOR EXPOSURE TO DUST AND WIND, ETC.

GROUP C

40. Styles.

Goggles of styles 1, 2, and 3 are permissible styles. They need not comply with any strength tests.

41. Specifications.

(*a*) *Goggle Frames.*—Frames and temples shall be substantially made. Eyecup goggles shall comply with rule 23.

(*b*) *Lenses.*—Lenses shall transmit not less than 70 percent of the visible light from the standard source specified in rule 154 (*a*). (See also rule 16.)

SECTION 5. PROTECTORS FOR BABBITTING, ETC.

GROUP D

50. Styles.

A face mask and goggles of styles 1, 2, and 3 are permissible styles. They need not comply with any strength tests.

51. Specifications for Masks.

Face masks may be of woven wire, the openings of which shall not exceed 0.0295 in. (0.75 mm), vulcanized fiber, or

equivalent material which can be sterilized without deterioration.

Masks shall be designed to hold lenses of dimensions specified in rule 53.

52. Specifications for Goggle Frames.

Frames of goggles of styles 1 and 2 shall conform to the requirements of rule 22 (except that the requirements of rule 22 (*c*) for side shields do not apply to goggles of style 1). Goggles of style 3 shall conform to the requirements of rule 23.

Lens containers shall be so constructed as to retain the parts of the lens in position if it should become cracked.

53. Specifications for Lenses.

Lenses shall have a thickness not less than 0.079 in. (2 mm).

If a single window is used in place of separate lenses, it shall have dimensions not less than 4.25 in. (10.8 cm) in one horizontal direction and not less than 2 in. (5.1 cm) in the vertical direction.

Lenses shall transmit not less than 70 percent of the visible light from the standard source specified in rule 154 (*a*). (See also rule 16.)

SECTION 6. PROTECTORS FOR HANDLING CORROSIVE CHEMICALS, DIPPING, BRUSH COATING, ETC.

GROUP E

60. Styles.

Eyecup goggles of style 3, face masks, and hoods are permissible styles. They need not comply with any strength tests.

61. Specifications for Goggles.

(*a*) *Goggles for Handling Acids, Caustics, etc.*—Eyecups shall be of soft, pliable rubber or equivalent noninflammable material and shall be flexible enough to conform readily to the configuration of the face. A suitable headband or headgear shall be provided, and it shall be impossible for splashing

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liquids to enter the eyes through the openings provided for ventilation. Where the presence of fumes would cause discomfort to the wearer if ventilating ducts were provided, goggles without ventilating openings shall be used.

(*b*) *Goggles for Use in Dipping and in Brush Coating.*—Eyecups shall conform to the requirements of rule 23. The design having solid eyecups, except for a single ventilating opening near the lens, is preferable. If the volume of fumes arising from the work is great, the eyecups shall be padded so that they fit the face closely, or else respirators with goggles shall be worn.

62. Specifications for Face Masks.

Face masks shall be of metal, vulcanized rubber, fiber, or equivalent material and shall have no openings in the front of the mask other than required for lenses. Masks shall be so shaped as to effectively protect the entire face.

63. Specifications for Hoods.

Hoods shall cover the head and neck completely and shall extend below the shoulders so as to effectively exclude gases. If a hood is supplied with air from an external source, the protector shall meet the requirements of rule 102 (*e*) and (*f*) or 103 (*d*) and (*f*).

64. Specifications for Lenses.

If a single window is used in place of separate lenses, it shall have dimensions not less than 4.25 in. (10.8 cm) in one horizontal direction and not less than 2 in. (5.1 cm) in the vertical direction.

Lenses shall transmit not less than 70 percent of the visible light from the standard source specified in rule 154 (*a*). (See also rule 16.)

For processes which will undesirably affect the surface of the glass either by deposits or chemical action, lenses of other material than glass, suitable for the process concerned, may be used. Lenses of cellulose acetate or other material substantially free from striae, air bubbles, waves, and other flaws may be used.

SECTION 7. PROTECTORS FOR EXPOSURE TO GLARE

GROUP F

70. Styles.

Goggles of styles 1, 2, and 3 are permitted. They need not comply with any strength tests.

71. Specifications.

(*a*) *Frames.*—The frames of goggles shall be substantially constructed.

(*b*) *Lenses.*—Lenses shall meet the tests for transmission of radiant energy prescribed in rule 154 (*b*). (See also rule 16.)

SECTION 8. PROTECTORS FOR OXYACETYLENE WELDING, FURNACE WORK, ETC.

GROUP G

80. Styles.

Goggles of styles 1, 2, and 3, face masks, helmets, and shields are permitted. They need not comply with any strength tests.

81. Goggles of Style 1 or 2.

The frames shall conform to the specifications given in rule 22 (except that the requirements of rule 22 (*c*) for side shields do not apply to goggles of style 1). To prevent burning, a heat-insulating material which can be sterilized without deterioration shall be used on all parts touching the face.

82. Eyecup Goggles, Style 3.

Goggles shall consist of eyecups of noncorrodible opaque material, which can be sterilized without deterioration. They shall be shaped to fit the configuration of the face. They shall exclude light, except through the lenses, but shall afford adequate ventilation. Parts touching the face shall be made of heat-insulating material. The eyecups shall be connected by a flexible coupling which will permit ready adjustment, or else goggles shall be furnished in assorted sizes.

The coupling shall be covered with or made of heat-insulating material. It shall withstand sterilization or be easily renewable. Goggles shall have a headband or headgear of any suitable material which will retain the goggles in their proper position.

83. Face Masks.

(*a*) *Masks and Headgear.*—Face masks shall be of fiber or equivalent material, which can be sterilized without deterioration and be shaped so as to protect the face of the operator above the mouth. Face masks shall have a headband or headgear of any suitable design and material so as to retain the mask in proper position.

(*b*) *Lens Containers.*—If a single window is used in place of separate lenses, it shall hold glass the dimensions of which are not less than 4.25 in. (10.8 cm) in one horizontal direction and 2 in. (5.1 cm) in the vertical direction. Containers shall be designed to accomodate cover glasses to protect the lenses. The design shall permit ready renewal of lenses.

84. Helmets and Shields.

(*a*) *Helmets.*—Helmets of the design specified in rule 91 (*a*) are permitted.

(*b*) *Shields.*—Shields as specified in rule 91 (*b*) are permitted.

85. Specifications and Tests for Protective Glass.

(*a*) *Optical.*—Lenses shall meet the transmission test for radiant energy prescribed in rule 154 (*c*).

Lenses constructed of two parts may be used if the lower half conforms to the requirements of rule 154 (*c*).

(*b*) *Marking.*—Glasses, except cover glasses, shall bear some permanent distinctive marking by which the source may be readily identified.

(*c*) *Cover Glasses.*—Cover glasses should be provided to protect the lenses. They shall be substantially free from striae, air bubbles, and other flaws, and shall have substantially parallel surfaces. (See also rule 16.)

SECTION 9. PROTECTORS FOR ELECTRIC ARC WELDING AND CUTTING

GROUP H

90. Styles.

The helmet and the shield are the only permissible styles.

NOTE.—The operator may need a respirator in addition to helmet or shield, or an air-supplied shield, if fumes or gases are produced.

91. Specifications for Protectors.

(*a*) *Helmets.*—Helmets shall be made of a material which is an insulator for heat and electricity, is not readily flammable, and is capable of withstanding sterilization. They shall be arranged to protect the face and ears from direct radiant energy from the arc. Helmets shall be provided with one or two windows arranged to accommodate and hold securely window glasses of the dimensions specified in rule 92, single or multiple, with cover glass, and designed to permit easy renewal of the glasses. Absorptive glasses shall be so mounted as to be not less than 2 in. (5.1 cm) from the eyes.

If supported by headgear the weight of the helmet, complete, shall not exceed 24 oz (680 g).

(*b*) *Shields.*—The shield shall consist of opaque material which is an insulator for heat and electricity. It shall be of such size and so shaped that it will protect the face from all direct radiant energy and shall be provided with a single window of the dimensions specified in rule 92, fitted to carry glasses single or multiple.

92. Specifications and Tests for Windows.

(*a*) *Optical.*—Windows shall meet the tests for transmission of radiant energy prescribed in rule 154 (*c*). (See also rule 16.)

(*b*) *Dimensions.*—Windows for both helmets and shields shall have height not less than 1.75 in. (4.4 cm) and width not less than 3.75 in. (9.5 cm) where one window is provided, or 1.75 in. (4.4 cm) where two windows are provided. These dimensions apply to the opening unobstructed by any opaque substance.

(*c*) *Marking.*—Glasses, except cover glasses, shall bear some permanent distinctive marking by which the source may be readily identified.

(*d*) *Cover Glass.*—A cover glass should be provided to protect the window. It shall be substantially free from striae, air bubbles, and other flaws, and shall have substantially parallel surfaces.

93. Protection for Other Workers.

A guard or shield shall be provided where necessary to protect other workers from exposure to the radiation from the electric arc, and no employee shall be required to work in such a position that his face is exposed to such radiation from any neighboring source.

It is recommended that permanent inclosures be supplied, where practicable, for arc welding and cutting.

SECTION 10. PROTECTORS FOR EXPOSURE TO DUST, FUMES, MISTS, SMOKES, OR OTHER ATMOSPHERIC PARTICULATE MATTER

GROUP I

100. Styles.

A mechanical-filter respirator, an air-line respirator, a hose mask, or an oxygen breathing apparatus is permissible.

101. Mechanical-Filter Respirator.

(*a*) *General.*—These respirators shall be complete with all requirements for safe use against the types of atmospheric particulate matter for which they are designed. They may include a chemical filter if desired, or if simultaneous protection is required by a protector of group *K*.

These respirators shall be constructed in all their parts of materials obviously suitable for the purpose they serve. This applies to the fabric, rubber, metal, and other parts. All rubber parts that come in contact with the skin shall be of a nonirritating composition. Rubber shall meet the requirements of rule 156. The rubber and metal parts shall withstand sterilization as specified in rule 140.

The respirator when in place on the wearer shall permit the use of various types of goggles without impairing the effectiveness of either goggles or the respirator, or the goggles may be permanently attached to the respirator, or a full facepiece as in a gas mask may be used.

(*b*) *Parts.*—Mechanical-filter respirators shall consist of a mechanical filter, inhalation valve, exhalation valve, a facepiece, or a mouthpiece and nose clip, and a suitable head harness or equipment for retaining the respirator comfortably and snugly in its proper position.

(*c*) *Mechanical Filter.*—All of the wearer's inspired air shall be drawn through the mechanical filter.

The filter shall remove mechanically generated dust to the extent prescribed in rule 155.

The arrangement of the filter shall be such as to permit it to be cleaned or replaced readily without leakage of unfiltered air after such changes have been made.

(*d*) *Facepiece.*—The facepiece shall not interfere with the wearer's safety, vision, or freedom of movement, and it shall be reasonably comfortable; and facepieces of other than the full-face type shall not interfere with the wearing of goggles.

(*e*) *Head harness.*—The straps of the head harness shall be adjustable and replaceable.

(*f*) *Tests.*—

(1) All respirators shall meet the requirements of the tests given in rule 155 (*a*) and (*h*).

(2) Respirators which also meet the requirements of the tests given in rule 155 (*b*), (*c*), (*d*), (*e*), (*f*), and (*g*) may be used for protection against any form of dust, fume, or mist which is no more harmful than the test suspensions used.

(3) Respirators which meet the requirements of the tests given in rule 155 (*a*), (*b*), and (*h*) may be used for protection against any form of pneumoconiosis-producing or nuisance dust that is no more harmful than free silica.

(4) Respirators which meet the requirements of the tests given in rule 155 (*a*), (*c*), (*d*), and (*h*) may be used for protection against any form of fume whose safe concentration by weight is not less than 0.000079 grain per cu ft (0.15 mg per cu m) of air.

(5) Respirators which meet the requirements of the tests given in rule 155 (*a*), (*e*), (*f*), (*g*), and (*h*) may be used for protection against mists having similar physical characteristics and which are no more harmful than the test suspensions used.

(6) Respirators intended for use in atmospheres containing a specific dust, fume, or mist may be qualified by passing a test in which such dust, fume, or mist is used, if it is demonstrated that the amount of atmospheric particulate matter passing through the respirator filter is below the tolerance limit.

NOTE.—If the particulate matter is irritating to the skin, special protection, such as the use of ointment, may be necessary.

102. Air-Line Respirator.

(*a*) *General.*—These respirators shall be constructed in all their parts of materials obviously suitable for the purpose they are to serve. This applies to the fabric, rubber, metal, and other parts. All rubber parts that come into contact with the skin shall be of a nonirritating composition. Rubber, except rubber used in hose, shall meet the requirements of rule 156. The rubber and metal parts shall withstand sterilization as specified in rule 140.

(*b*) *Parts.*—The respirator shall comprise a facepiece with head harness, exhalation valve, and breathing tube. The breathing tubes shall connect to a hose, which shall be supported so as to permit free head movement and not be subject to closing off by kinking or by chin or arm pressure while the respirator is being worn. The hose shall be supplied with respirable air under positive pressure.

(*c*) *Facepiece.*—The distribution and velocity of the air within the facepiece shall be such as not to cause discomfort to the wearer. The head harness may consist of elastic headbands which are adjustable and replaceable.

(*d*) *Breathing Tubes.*—The breathing tube may be an extension of the type of hose used for conveying the air from the point of supply, or it may be one or two lengths of flexible, nonkinking hose that extends from the facepiece to a point of connection on the belt or harness.

(*e*) *Supply Hose.*—The supply hose shall comply with the test given in rule 157 (*d*). When tested as an assembled part of the respirator and connected to an air supply at the operating pressure specified by the manufacturer, the air flow shall be not less than 6 cu ft (170 liters) per min with adjustments or regulators open, nor less than 2 cu ft (57 liters) per min with adjustments and regulators in the closed position.

Any source of safe, respirable air at the elevated pressure required for proper operation may be used. It is recommended that a separator trap be provided to intercept oil, water, and other extraneous matter.

(*f*) *Valves, Couplings, and Air-Regulating Mechanism.*—The respirator shall be equipped with a convenient, durable, and dependable mechanism for controlling the supply of air to meet the demands of the wearer. Suitable means shall be provided to guide the wearer in the adjustment of the device to an air-flow that does not permit a negative pressure within the facepiece at any instant of inspiration. It shall also control the positive pressure within the facepiece to a value not in excess of 1 in. (25 mm) of water column with an air flow into the facepiece of 6 cu ft (170 liters) per min. This may be in the form of a simple regulating valve in the supply line at the belt, and a relief valve on the facepiece which will indicate the required slight excess by remaining in an open position throughout the entire cycle of breathing, or any other foolproof telltale control or indicating device.

The respirator shall also be equipped with an air-limiting valve or mechanism which will limit the supply of air to not less than 2 cu ft (57 liters) per min nor more than 20 cu ft (566 liters) per min if connected in the recommended manner to an air supply at the operating pressure specified by the manufacturer.

If the specified operating pressure is in excess of 5 lb per sq in (0.35 kg per sq cm), a pressure-release mechanism shall be provided which will prevent the pressure at the air-flow adjustments or regulators from exceeding 25 lb per sq in (1.75 kg per sq cm).

For the purpose of these requirements the operating pressure is that pressure existing in the hose at a point down stream from the general air supply or any pressure-reducing valve.

A hand-operated detachable coupling by means of which the wearer can easily and quickly make attachment or detachment at a point near the harness shall be provided. This coupling shall be durable, remain connected under all conditions of reasonable use of the respirator, and meet all the tests for strength and tightness.

103. Hose Mask.

(*a*) *General.*—These respirators shall be constructed in all their parts of materials obviously suitable for the purpose they are to serve. This applies to the fabric, rubber, metal, and other parts. All rubber parts that come into contact with the skin shall be of a nonirritating composition. Rubber, except that used for the hose, shall meet the requirements of rule 156. The rubber and metal parts shall withstand sterilization as specified in rule 140.

(*b*) *Parts.*—The hose mask shall comprise a facepiece with head harness, inhalation and exhalation valves, and one or more breathing tubes. The breathing tube shall connect to a hose supported by the body harness, and reaching to an intake of respirable air. A hand-operated blower may or may not be connected to the supply end of the hose, except that for emergency work, a hand-operated blower is mandatory.

(*c*) *Facepiece.*—The facepiece shall be designed to permit inhalation through the nose, in event that a blower is not operated, without leakage of irrespirable gases. Only full or Tissot types, which form a pocket over the face and allow breathing through the nose are permissible. No device with a direct mouth or nose connection is permitted. Elastic headbands shall be adjustable and replaceable. In devices where the windows or lenses are required to give protection to the eyes, as from flying particles, splashing of molten metal, or harmful light, they shall be of a type that meet the requirements for goggles or other protectors for similar hazards.

The distribution and velocity of the air within the facepiece shall be such as not to cause discomfort to the wearer. The head harness may consist of elastic headbands which are adjustable and replaceable. The exhalation valve shall be guarded to prevent distortion or other injury.

(*d*) *Breathing Tubes.*—One or two flexible rubber breathing tubes of the nonkinking type shall extend from the facepiece to a connecting hose coupling attached to the belt or body harness to conduct air from the hose to the facepiece. These tubes shall permit free head movement while the device is being worn.

The supply hose shall not exceed 150 ft (46 m) in length and shall meet the test requirements of rule 157 (*a*).

The resistance to inhalation shall not exceed 2.5 in. (63.5 mm) of water-column height to air flowing at a rate of 3 cu ft (85 liters) per min, when tested as prescribed in rule 155 (*a*).

(*e*) *Body Harness.*—The harness shall be made of leather, fabric webbing, or equivalent material. Material, joints, and seams of shoulder straps shall separately withstand a pull of 250 lb (113 kg) without failure. Belts, rings, and attachments for life lines shall withstand a pull of 300 lb (136 kg) without failure. The hose shall be firmly attached to the harness so as to withstand a pull of 250 lb without separating, and the hose attachments shall be arranged so that the pull or drag of the hose behind an advancing wearer does not disarrange the harness or exert pull upon the face-piece. Harness shall be adjustable to various sizes.

(*f*) *Supply Hose.*—If no blower is used, the inlet to the hose shall have a terminal fitting or chamber which provides for drawing the air through 200-mesh high-chrome-nickel wire screen (stainless steel) with an adjustable leather or webbing strap at least 18 in. (46 cm) long for fastening or anchoring the end to a fixed position in the zone of clean fresh air. If provided with a hand-operated blower it shall permit free entrance of air to the hose when the blower is not operated; and the blower shall deliver the amount of air hereinafter specified with either direction of rotation, unless the construction of the blower is such that it can be operated only in one direction.

In a multiple system, whereby more than one man is supplied by one blower, each hose line shall be connected directly to a manifold at the blower.

The hose-mask blower shall meet the test requirements of rule 157 (*b*).

104. Oxygen Breathing Apparatus.

(*a*) *General.*—These devices shall be complete with all requirements for safe use by specially trained wearers in furnishing protection in irrespirable atmospheres containing no harmful constituent which can be absorbed through the skin.

Each device shall have marked on it distinctly the name and address of the manufacturer, and the name, letter, or number by which the device is identified.

The regenerating material shall absorb from the expired air carbon dioxide to the extent that not more than 2.5 percent shall at any time be present in the inspired air. The average shall not exceed 1 percent for the duration of the periods of test. This average is to be determined by the analyses of air samples taken as near the point of inspiration as practicable and at uniform intervals of time.

The apparatus shall be sufficiently free from mechanical obstructions in order that the wearer may breathe freely at all times.

The apparatus shall be sufficiently durable in construction and all vital parts so protected as to prevent material damage or wear to the apparatus.

(*b*) *Construction.*

(1) The apparatus shall be of a design using a mouth-breathing device or other face attachment. The apparatus shall not weigh more than 40 lb (18 kg) complete with head-piece and fully charged.

(2) The mechanical construction of the apparatus shall be such that every part can be tested, inspected, and repaired by persons skilled in such work, and all parts which require sterilizing shall be readily accessible for this purpose.

(3) All parts of the apparatus subject to or liable to be subjected to internal pressures in excess of 5 lb per sq in. (0.35 kg per sq cm) shall be of such construction or equipped with such safety devices as shall insure the safety of the wearer.

(4) In apparatus equipped with breathing bag or bags, or their equivalent, the inhalation and exhalation compartments shall have a combined capacity of at least 488 cu in. (8 liters). If a single breathing bag is used it shall have a capacity of at least 305 cu in. (5 liters).

(5) When the breathing bag is used in conjunction with the operation of the oxygen admission valve the bag shall have a capacity for at least 183 cu in. (3 liters) of air above the closing-off point of the admission valve, and after 3 liters of air is introduced in the bag, the water-gage pressure shall not exceed 3 in. (7.6 cm).

(6) Breathing bag shall consist of such material that will exclude mine gases and be impervious to gasoline fumes for at least a 2.5-hr period; the material shall be strong, flexible, and the seams shall either be cemented and sewed or vulcanized or bound in such manner that the bag will not come apart at the seams under wearing conditions; or the bag may be made of one piece.

(7) The apparatus shall not have in its circulating system any zone of constant negative pressure, nor a positive pressure at the mouthpiece of more than 3 in. (7.6 cm) water gage after a 153-cu in. (2.5-liter) exhalation.

(8) The apparatus shall be provided with a release valve, operated by hand or automatically, placed at some point in the circulatory system of the apparatus. The function of this valve shall be to permit the escape to the outside air of a part of the air in the circulatory system of the machine. The valve shall be so designed that no outside air can be drawn into the apparatus on inhalation.

(9) If apparatus is equipped with high-pressure oxygen cylinders, such cylinders shall be tested in accordance with the Interstate Commerce Commission specifications 3–A.

(10) If apparatus is equipped with high-pressure oxygen cylinders the safety cap attached to the closing valve shall, in addition to the usual copper disk provided, be filled with a metal (such as Rose's metal) fusing at a temperature of approximately 94° C. Such fusible metal shall not extrude from the safety cap under a pressure of 150 atmospheres.

(11) The closing valve of such oxygen cylinders shall be provided with the necessary device to prevent the wearer of the apparatus from screwing the stem entirely out of the valve. The closing valve shall also be provided with such a device as will enable the wearer to lock the valve stem open when the valve has been opened to the desired point. The valve-closing device shall be operable by hand and without intervention of wrenches or external levers.

(12) If apparatus is equipped with gages for recording time or pressure of oxygen supply, such gages shall be tested for accuracy.

(13) The apparatus shall be equipped with a valve that will cut off the oxygen supply from the gage; this valve shall

be so placed that it can readily be manipulated by the wearer by hand and at the same time not interfere with the flow of oxygen from the oxygen container to the circulatory system of the apparatus.

(14) The gage shall be placed on the apparatus at such a point that it can easily be read by the wearer.

(15) Apparatus equipped with a reducing valve giving a constant or automatic flow of oxygen shall be provided with a bypass valve which will permit a free flow of oxygen from the oxygen container to the circulatory system of the apparatus independent of the reducing valve.

(16) If the oxygen supply of the apparatus is controlled by automatic devices, such devices shall readily adjust themselves to the needs of the wearer.

(17) If an apparatus is equipped with mouth-breathing device, such apparatus shall be provided with an adequate saliva trap so designed that during the operation of the saliva trap no surrounding atmosphere can be drawn into the apparatus during inhalation.

(18) If an apparatus is equipped with mouth-breathing attachment, a suitable nose clip shall be provided and properly attached to the apparatus.

(*b*) *Tests.*—Oxygen breathing apparatus shall pass the tests presbribed in rule 159.

SECTION 11. PROTECTORS FOR ABRASIVE BLASTING

GROUP J

110. Styles.

An abrasive-blasting respirator which incorporates a hood or helmet is the only style permitted. The respirator shall comply with all the requirements for an air-line respirator as contained in rule 102 or else all the requirements for a hose mask as contained in rule 103, except that a mechanical-filter respirator complying with section 10 may be used if the concentration of particulate matter is known to be less than 400 million particles per cu ft (14,000 million per cu m) as determined by the impinger method used by the United States Public Health Service.[1]

[1] L. Greenburg and J. J. Bloomfield. *The impinger dust sampling apparatus as used by the United States Public Health Service.* Public Health Rep, **47**, 654–675 (1932).

Note.—Abrasive blasting may be conducted in closed automatic apparatus, or in cabinets manually operated from the outside so that the operator is not directly subjected to the dust-laden atmosphere. Such arrangements are recommended and if the dust count is maintained below the recognized limits of tolerance, it is not necessary for the operator to wear a protector.

111. Hoods and Helmets.

A hood or helmet shall cover the head and neck completely so as to give mechanical protection from flying particles. A helmet shall rest on the shoulders or shall be provided with suitable harness to hold it comfortably in place and prevent the wearer's head from coming in contact with the sides.

112. Windows.

A window of transparent material of a grade suitable for optical use shall be furnished for each eye of the operator or one window for both. It shall transmit not less than 80 percent of the incident light, and be not less than 0.093 in. (2.38 mm) in thickness, and shall comply with rule 16. If two windows are used, each shall have a horizontal dimension not less than 2.5 in. (6.35 cm). If a single window is used it shall have dimensions not less than 4.25 in. (10.8 cm) in one horizontal direction and not less than 2 in. (5.1 cm) in the vertical direction.

113. Screens.

A woven-wire or perforated sheet-metal screen or cover material which does not interfere unduly with vision shall be used in front of the windows in the headpiece. The screen shall be mounted and attached in a manner which will permit easy access to the external surface of lenses or windows for cleaning. All screens, lenses, and windows subject to abrasion shall be easily replaceable. Means shall be provided to prevent fogging or dusting of the lenses or windows.

114. Man Test.

The man test specified in section 4, page 17, of Schedule 19A of the United States Bureau of Mines, for abrasive-blasting protectors, shall be complied with.

SECTION 12. PROTECTORS FOR EXPOSURE TO IRRESPIRABLE GASES AND VAPORS

GROUP K

120. Styles.

The hose mask, oxygen-breathing apparatus, gas mask, cartridge-type chemical-filter respirator, or air-line respirator is permissible in atmospheres containing no constituents that can be absorbed through the skin in harmful quantities.

The hose mask with blower may be used for unlimited exposure to any atmosphere with the above exceptions.

The oxygen-breathing apparatus may be used for limited exposure to any atmosphere with the above exceptions.

The gas mask may be used for limited exposures to certain gaseous contaminants in air containing sufficient oxygen for respiration. In general, they should not be used in concentrations exceeding the values given in rule 123.

The air-line respirator may be used for unlimited exposure to any atmosphere which will not jeopardize the wearer's life if the respirator is momentarily removed, or from which the wearer could escape safely without the use of the respirator.

The cartridge-type chemical-filter respirator may be used for protection from exposure to certain atmospheric gaseous contaminants which are present only in concentrations so low as to be hazardous only after long or repeated exposures.

NOTE.—If a gas or vapor is irritating to the skin, special protection, such as the use of an ointment, may be necessary.

121. Hose Masks and Air-Line Respirators.

Hose masks and air-line respirators used for the purposes covered by this section shall comply with rule 103 or 102, respectively.

122. Oxygen Breathing Apparatus.

Oxygen breathing apparatus shall comply with rule 104.

123. Gas Masks.

(*a*) *General.*—Gas masks (canister-type chemical-filter respirators) shall be of such design and construction as to protect the respiratory organs of the wearer from acid gases and organic vapors, ammonia and carbon monoxide, either singly or in combination, where the surrounding atmosphere contains sufficient oxygen for respiration. They shall be of such design as to insure a gas-tight fit when in proper position on the wearer, and shall meet the requirements of rule 158 (*g*).

(*b*) *Parts.*—Gas masks shall consist of the following principal parts:

(1) Facepiece with exhalation valve and lenses, and with head harness and breathing-tube connections similar to those for hose masks (see rule 103). It shall fit the face of the wearer comfortably and shall be free from leaks. In lieu of this, the breathing tube may lead to a mouthpiece equipped with exhalation valve, and a nose clip provided to prevent breathing through the nose.

(2) An inhalation valve in the assembly.

(3) A canister containing the proper absorbents and filters.

(4) If the canister is separate from the facepiece, there shall also be a substantial adjustable body harness and a rubber breathing tube similar to that for hose masks.

Canisters shall be easily replaceable.

(*c*) *Materials.*—The materials used in the construction of all parts shall be suitable for the purpose they serve. All parts, except canisters, shall withstand sterilization as specified in rule 140.

(*d*) *Facepiece, Head Harness, Lenses, Breathing Tube, and Valves.*—These parts shall meet the requirements for similar parts of hose masks in rule 113, except that no check valve is necessary in the breathing-tube–facepiece assembly.

(*e*) *Body Harness.*—A body harness shall be comfortable and shall allow free movement of the wearer. It shall be so designed and arranged as to support and hold the canister securely in its proper place.

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(*f*) *Canisters.*

(1) Canisters shall be marked to conform with the American Standard Code for Identification of Gas-Mask Canisters.

(2) For protection in concentrations not exceeding 1 percent of organic vapors, such as alcohol, acetone, aniline, benzol, carbon bisulfide, carbon tetrachloride, chloroform, ether, formaldehyde, petroleum distillates, and toluol, canisters shall be capable of meeting the tests in rule 158 (*b*) and (*g*). For concentrations exceeding 1 percent, the 5-min test required in the second paragraph of rule 158 (*b*) shall be carried out with the specified concentration.

(3) For protection in concentrations not exceeding 1 percent of acid gases, such as chlorine, formic acid, hydrogen chloride, hydrogen cyanide, hydrogen sulfide, nitrogen peroxide, phosgene, and sulfur dioxide, canisters shall be capable of meeting the tests of rule 158 (*c*) and (*g*). For concentrations exceeding 1 percent, the 5-min test required in the second paragraph of rule 158 (*c*) shall be carried out with the specified concentration.

(4) For protection against ammonia gas in concentration not exceeding 1 percent, canisters shall be capable of meeting the tests of rule 158 (*d*) and (*g*). For concentrations exceeding 1 percent, the 5-min test required in the second paragraph of rule 158 (*d*) shall be carried out with the specified concentration.

(5) For protection against carbon monoxide in concentration not exceeding 1 percent for a period of 2 hrs or more, canisters shall be capable of meeting the tests of rule 158 (*e*). For concentrations exceeding 1 percent, the 15-min test required in the second paragraph of rule 158 (*e*) shall be carried out with the specified concentrations.

For protection for a period not exceeding 30 min, canisters shall be capable of meeting the tests specified in rule 158 (*f*).

(6) For protection against mixtures of the above gases in air, canisters shall be capable of meeting all of the tests applying for the individual gases.

(7) For protection against smoke, dust, or mists, either alone or in combination with gases or vapors, canisters shall include a mechanical filter which meets the requirements of rule 158 (*h*).

124. Cartridge-Type Chemical-Filter Respirators.

These respirators shall meet the requirements of rule 101, except as follows:

(1) A chemical-cartridge type of filter is substituted for the mechanical filter.

(2) Rule 101 (*f*) (6) does not apply.

(3) Only paragraphs (*a*) and (*h*) of rule 155 need be complied with.

SECTION 13. PROTECTORS FOR EXPOSURE TO HEAVY FALLING OBJECTS

GROUP L

130. Styles.

A reinforced head covering or cap is permissible.

131. Materials.

Materials used in the construction of the hat or cap shall be water-resistant, acid-resistant, fire-resistant, and nonconductors of electricity.

132. Construction.

The hat or cap shall be supported by a cradle fitting the head and this cradle shall be adjustable to give a good fit, and so designed as to be comfortable to the wearer. It shall be attached to the hat or cap in a strong and substantial manner, so that it will not tear loose. There shall be a space of at least 1 in. (25.4 mm) between the crown of the cap or hat and the top of the wearer's head. The hat or cap may have either a brim or a visor.

133. Strength.

The hat or cap shall meet the requirements of the drop test as given in rule 160 (*b*).

134. Electrical Protection.

Caps or hats used in mining shall meet the test for dielectric breakdown given in rule 160 (*c*).

SECTION 14. OPERATING RULES

140. Sterilization.

Goggles, respirators, and other protectors shall not be interchanged among employees unless they have been sterilized. Previous to sterilization they should be scrubbed with soap and hot water. The following methods for sterilization are recommended:

(1) Subjection to a moist atmosphere of antiseptic gas, such as formaldehyde, for a period of 10 min.

(2) Immersion in boiling water for a period of 5 min.

(3) Immersion for a period of 10 min in a solution of formalin made by dissolving 1 part of 40-percent formaldehyde in 9 parts of water.

(4) Immersion in live steam for a period of 5 min.

NOTE.—The method recommended by the manufacturer of the protector should be followed.

141. Supply and Fitting of Protectors.

The employer shall advise his employees where within the works protectors may be obtained, and employees shall not be put at work where protectors are needed without being provided with them. Care shall be exercised to properly adjust protectors which are not an exact fit, to secure the greatest comfort consistent with adequate protection. Particular attention should be given when fitting goggles to be sure that the eyelashes of the wearer do not touch the surface of the glass.

A duly appointed agent or employee should be assigned the duty of distributing and fitting eye protectors, caps, masks, respirators, etc., as a result of indicated or demonstrated ability to perform this duty efficiently.

142. Replacement of Defective Protectors.

The employees shall be responsible for immediately reporting any broken or otherwise defective protectors, and for making application to the employer for their repair or replacement.

The employer shall be responsible for making suitable arrangements for the proper replacement of protectors or their defective parts.

Employees shall never wear defective protectors. Broken or damaged parts shall be replaced by new parts before the protectors are again used.

143. Inspection of Protectors.

It is recommended that periodical inspection of all protectors be made by the employer or his authorized representative so that the wearing of clean protectors in good condition will be assured.

Respirators, abrasive-blasting hoods and helmets, masks, and canisters should be tested for leaks.

SECTION 15. TESTS FOR PROTECTORS

150. Scope of Tests.

The following tests for protectors are intended to assure adequate strength and other necessary qualities of protectors used in the operations and processes named in the rules of the foregoing sections in which tests are required. The quantity of any item to be tested shall be determined by the proper administrative authority.

In many instances it will be satisfactory, and in some instances it is essential, that compliance of a given model with the code requirements be determined by testing one or more samples, rather than by testing each protector to be used. The suitability of such a model for a given purpose can thus be established.

151. Mechanical Tests for Frames of Goggles.

(*a*) *Flat Transverse Test.*—Each frame tested shall have the right lens container laid flat, with the outer surface of the lens downward, on a firm, level support so that the left lens and one-half of the bridge projects beyond the edge of the support and shall be held in this position. A spring balance shall be attached to the outermost portion of the frame of the left lens, and a downward force of 8 oz (226 g) shall be applied while the right lens frame is rigidly held. After removal of the load no permanent deformation shall be apparent in the frame.

(*b*) *Edge Transverse Test.*—Each frame tested shall have the right-lens container held vertically in one hand and the

lower edge of the left lens container, as worn, pressed against one of the platforms of an equal-arm balance having a weight of 4 lb. (1.82 kg) on the other platform. The pressure shall be increased until the weight is balanced, whereupon the frame is removed and examined. No permanent deformation shall be apparent in the frame.

(*c*) *Strength Test for Lens Containers.*—Lens containers shall be substantial in construction and each container tested shall withstand, without distortion, the drop test prescribed in rule 153.

(*d*) *Test of Joints.*—If the lens containers are rigidly joined by a separate bridge or nose piece in any manner whatsoever, the joints shall be given the following tests to demonstrate their strength and durability. Goggles which have already passed the strength tests of paragraphs (*a*), (*b*), and (*c*) above may be used for this purpose. The lens containers with lenses in place shall be gripped one in each hand, the thumbs bearing on the outer surface near the bridge and the fingers on the inner surface of the lenses near the junction of the bridge and the lens container. The frames shall then be slowly bent, the direction of motion being in a plane perpendicular to the surface of the lenses, until the outer surfaces of the lenses face each other, the outer ends of the frames touching. The frames shall then be bent back to their original shape and a careful inspection made for failure in the joints. All frames tested shall pass this test without developing visible cracks.

Note.—If the bridge is constructed with individual members of the bridge in more than one plane parallel to the surface of the lenses, all of the members except those attached to the rims of the lens containers shall be cut and the above test applied to the remaining members.

152. Test for Corrosion.

The corrodibility of the metal of the frame and side shields shall be determined by immersing a pair of goggles in a boiling aqueous 10-percent (by weight) solution of sodium chloride for a period of 15 min. The frames upon being removed from this solution shall be immediately immersed in a 10-percent (by weight) aqueous solution of sodium chloride at room temperature. They shall then be removed from this solution and, without having the adhering liquid wiped off,

allowed to dry for 24 hr at room temperature. The metal parts shall then be rinsed in lukewarm water and allowed to dry. On inspection the surface shall still be smooth.

153. Mechanical Tests for Lenses.

Drop Test.—Lenses shall be submitted to one of the following tests.

(*a*) A spherical steel ball of 0.565 ±0.011 oz (16.0 ±0.3 g) in weight, approximately 0.625 in. (1.59 cm) in diameter shall be dropped from a height of 39.4 in. (1 m) on the center of the horizontal outer surface of the lens. The lens shall be placed flat on the end of a wooden tube having a rim to fit the lens. The tube shall have an internal diameter of 1.77 in. (45 mm), shall be not more than 2 in. (51 mm) long, and shall be supported on a steel block. A washer of rubber packing, not more than ⅛ in. (3 mm) thick, and of same internal diameter as the tube, shall be placed between the lens and the tube. The rubber shall be of the quality required for a grade A gasket in Federal Specification HH–G–156. If one out of six lenses is fractured in this test, four more lenses shall be tested, and if any one of these is fractured the lot shall be rejected.

(*b*) A spherical steel ball of 0.565 ±0.011 oz (16.0 ±0.3 g) in weight, approximately 0.625 in. (1.59 cm) in diameter shall be dropped from a height of 39.4 in. (1 m) on the center of the horizontal outer surface of the lens. The lens shall be supported as in paragraph (*a*) above. If one out of six lenses tested is fractured in such a way that a fragment of glass weighing more than 0.39 grain (25 mg) leaves the bottom surface, four more lenses shall be tested, and if one of these lenses fractures in the above-described manner the lot shall be rejected.

154. Optical Tests for Lenses.

(*a*) *Standard Source of Radiant Energy.*—The standard source of radiant energy used for the measurement of transmission of visible light or total radiant energy shall be a 200-w, 115-v, gas-filled, clear-glass, tungsten-filament, electric incandescent lamp operating at its commercial rating.

(*b*) *Lenses for Group F.*—Lenses shall transmit not more than 1 percent of radiant energy of any wave length less than

365 millimicrons. They shall transmit not more than 50 percent of the visible light incident upon them from the standard source.

(c) *Filter Glasses for Groups G and H.*—Filter glasses shall meet the requirements of the following table for the transmission of radiant energy:

Shade No.	Density for visible radiation [a]			Transmission (percent)							
				Total visible			Maximum total infrared	Maximum ultraviolet			
								For wave length, in millimicrons			
	Minimum	Standard	Maximum	Maximum	Standard	Minimum		313	334	365	405
3	0.64	0.857	1.06	22.9	13.9	8.7	9.0	0.2	0.2	0.5	1.0
4	1.07	1.286	1.49	8.51	5.18	3.24	5.0	.2	.2	.5	1.0
5	1.50	1.714	1.92	3.16	1.93	1.20	2.5	.2	.2	.2	0.5
6	1.93	2.143	2.35	1.18	0.72	0.45	1.5	.1	.1	.1	.5
7	2.36	2.572	2.78	0.44	.27	.17	1.3	.1	.1	.1	.5
8	2.79	3.000	3.21	.162	.100	.062	1.0	.1	.1	.1	.5
9	3.22	3.429	3.63	.060	.037	.023	0.8	.1	.1	.1	.5
10	3.64	3.857	4.06	.0229	.0139	.0087	.6	.1	.1	.1	.5
11	4.07	4.286	4.49	.0085	.0052	.0033	.5	.05	.05	.05	.1
12	4.50	4.715	4.92	.0032	.0019	.0012	.5	.05	.05	.05	.1
13	4.93	5.143	5.35	.00118	.00072	.00045	.4	.05	.05	.05	.1
14	5.36	5.571	5.78	.00044	.00027	.00017	.3	.05	.05	.05	.1

[a] Standard density is defined as the logarithm (base 10) of the reciprocal of the transmission. Shade number is determined by the density according to the relation:
Shade number = 7/3 density + 1.
with tolerances as given in the table.

155. Tests for Mechanical-Filter Respirators.

NOTE.—In carrying out the tests specified in this rule, the details given in Schedule 21 of the United States Bureau of Mines shall be followed.

(a) *Resistance to Air Flow.*—The resistance to flow of air of the complete respirator, as determined during or after the prescribed tests on a mechanical apparatus at a rate of airflow of 3 cu ft (85 liters) per min continuous flow, shall, on inhalation, not exceed 2 in. (50 mm) of water pressure; and

on exhalation shall not exceed 1.0 in. (25 mm) of water pressure. The method of test shall be similar to that given in United States Bureau of Mines Technical Paper 394, p. 28 (1926).

(*b*) *Filter for Dry Siliceous Dusts.*—Air containing 0.022 ±0.004 grain per cu ft (50 ±10 mg per cu m) of dust consisting of ground flint shall be passed through the respirator at a rate of 1.13 cu ft (32 liters) per min, at a temperature of approximately 25° C (77° F) and a relative humidity of 40 to 70 percent. The dust shall consist of not less than 99 percent free silica and at least 99 percent of it shall pass through a 325-mesh sieve. The geometric mean size of the particles in the test atmosphere shall be approximately 0.6 micron and the standard geometric deviation 1.90, as determined by the microprojection method used by the United States Bureau of Mines [2] or other suitable method. The amount of dust passing through the respirator in 90 min or when 101.7 cu ft (2.88 cu m) of the test suspension has passed, shall not exceed 0.062 grain (4 mg) for any one of three respirators, or an average of 0.046 grain (3 mg) for the three respirators.

With a concentration one-tenth that above, the amount of dust passing through the respirator in 5 hr 12 min, or when 352.4 cu ft (9.98 cu m) of the test suspension has passed, shall not exceed 0.185 grain (12 mg) for any one of three respirators, or an average of 0.154 grain (10 mg) for the three respirators.

(*c*) *Filter for Low-Plugging Fumes.*—Air containing 0.0066 ±0.0022 grain per cu ft (15 ±5 mg per cu m) of lead in the form of oxide fume produced by the decomposition and combustion of tetraethyl lead shall be passed through the respirator at a rate of 1.13 cu ft (32 liters) per min, at a temperature of approximately 25° C (77° F) and a relative humidity of 40 to 70 percent. The amount of lead passing through the respirator in 5 hr 12 min shall not exceed 0.00066 grain (1.5 mg).

(*d*) *Filter for Fast-Plugging Fumes.*—Air containing 0.0437 ±0.0109 grain per cu ft (100 ±25 mg per cu m) of freshly

[2] C. E. Brown and W. P. Yant, The Microprojector for Determining Particle-Size Distribution and Number Concentration of Atmospheric Dust, U. S. Bureau of Mines Report of Investigation 3289 (1935).

formed magnesium oxide shall be passed through the respirator at the rate of 1.13 cu ft (32 liters) per min, at a temperature of approximately 25° C (77° F) and a relative humidity of 40 to 70 percent. After 70.6 cu ft (2 cu m) of air have flowed through the respirator, the resistance to air-flow shall comply with the requirements of paragraph (*a*).

(*e*) *Filter for Chromic-Acid Mists.*—Air containing 0.0066 ±0.0022 grain per cu ft (15 ±5 mg per cu m) of chromic acid present as a mist shall be passed through the respirator at the rate of 1.13 cu ft (32 liters) per min, at a temperature of approximately 25° C (77° F). The chromic-acid mist shall be produced by electrolyzing an aqueous solution of chromic acid containing 6.7 to 16.7 oz per qt (200 to 500 g per liter) of chromic acid. The amount of chromic acid passing through the respirator in 5 hr 12 min shall not exceed 0.015 grain (1 mg).

(*f*) *Filter for Lead-Paint Mists.*—A test suspension containing between 0.13 and 0.26 grain per cu ft (300 and 600 mg per cu m) of lead shall be prepared by spraying into the air a paint composed of 3.5 oz (100 g) of white-lead paste (consisting of approximately 91 percent of white lead and 9 percent of linseed oil by weight), 1.7 fl oz (50 ml) of linseed oil, and 1.35 fl oz (25 ml) of steam-distilled turpentine. This suspension shall be passed through the respirator at the rate of 1.13 cu ft (32 liters) per min at a temperature of approximately 25° C (77° F) and a relative humidity of 40 to 70 percent. The amount of lead passing through the respirator in 5 hr 12 min shall not exceed 0.023 grain (1.5 mg).

(*g*) *Filter for Wet Silica Dust.*—A test suspension containing 0.0044 ±0.0022 grain per cu ft (10 ±5 mg per cu m) of silica dust shall be prepared by spraying into the air water containing 2 percent by weight of ground flint, air-floated, which consists of at least 99 percent free silica and 99 percent of which will pass through a 325-mesh sieve. This suspension shall be passed through the respirator at the rate of 1.13 cu ft (32 liters) per min at a temperature of approximately 25° C (77° F). The amount of silica passing through the respirator in 5 hr 12 min shall not exceed 0.077 grain (5 mg).

(*h*) *Man test.*—Three respirators shall be worn by three men having different facial contours (wide, narrow, etc.) in a room containing a plainly visible atmospheric suspension of powdered bituminous coal. The men shall exercise moderately and rest alternately in 5-min periods for a total elapsed time of 30 min. Both before and after the test an examination shall be made of the sputum, nasal discharge, nasal cavities, and external skin (where covered by the facepiece of the respirator) of each man. The examination shall not show any more black particulate matter after the test than before.

A test in which a stream of air containing a high concentration of coal dust is blown around the edges of the facepiece for several minutes may be substituted for the above test.

156. Tests for Rubber.

Soft rubber used in respirators or masks shall have a tensile strength not less than 1,700 lb per sq in (120 kg per sq cm). After being aged for 7 days in air at a temperature of 70 $\pm 1°$ C (158 $\pm 2°$ F) the tensile strength shall not have decreased more than 20 percent.

157. Tests for Hose Masks, Air-Line Respirators, and Abrasive Blasting Equipment.

NOTE.—In carrying out the tests specified in this rule, the details given in Schedule 19A of the United States Bureau of Mines shall be followed.

(*a*) *Hose for Hose Masks.*

(1) *Permeation by gasoline.*—Hose shall be tested for permeation by gasoline by immersing 25 ft of hose and a coupling in a bath of gasoline. Air will be passed through the hose at the rate of 0.28 cu ft (8 liters) per minute for 6 hr. The air from the hose shall not contain more than 0.01 percent of gasoline vapor at the end of this period.

(2) *Collapsibility.*—A hose shall not collapse when a force of 200 lb (91 kg) is applied between two hard plane surfaces to a 3-in. length of the hose.

(3) *Strength of Couplings.*—Hose and couplings shall not show any separation or leakage when subjected to a pull of 250 lb (93 kg).

(4) *Tightness.*—Hose with couplings shall withstand without leakage an internal air pressure of 5 lb per sq in. (0.35 kg per sq cm).

(*b*) *Blower for Hose Mask.*—The blower shall be operated with mechanical power 6 to 8 hr daily for a total of 100 hr at the speed required to deliver 1.8 cu ft (50 liters) of air per min through the mask, assembled with the kind and maximum length of hose for which the device is to be used, connected to each blower or manifold outlet designed for hose connections. During this test period the blower shall be oiled and given attention and care. It must operate throughout the period without failure or indication of excessive wear of bearings or working parts. The crank speed required to deliver the specified 1.8 cu ft of air per min shall not exceed 50 rpm; the power required shall not exceed 1/60 hp (12 watts), and the torque shall not exceed a force of 5 lb (2.27 kg) on an 8-in. (20.3 cm) crank.

When assembled with the facepiece and 50 ft (15.2 m) of the hose with which it is to be used connected to one outlet, with all other outlets closed, and operated at any practicable speed up to 50 revolutions of the crank per min, the amount of air delivered through the facepiece shall not exceed 5.3 cu ft (150 liters) per min, and the pressure at the hose connection to the blower or manifold shall not exceed the equivalent of 5 in. (12.7 cm) of water. If relief valves are employed to fulfill this requirement they shall operate automatically and be simple in design, durable, and foolproof against failure to open.

(*c*) *Resistance to Air-Flow.*—The facepiece and hose (in the maximum length with which the device is to be used) connected to blower (if any) shall not show resistance in excess of 2.5 in. (63.5 mm) of water-column height to air flowing at a rate of 3 cu ft (85 liters) per min when the blower is not operating or under any practical condition of blower operation. Resistance at the exhalation valve shall not exceed 1 in. (25 mm) of water-column height.

If inlet valves at the blower are used to meet the requirement for resistance to inhalation through the hose they shall operate automatically and be simple in design, durable, and foolproof against failures which would tend to close the

inlet. Inlet valves and blower inlets shall be provided with durable metal guards that will protect against fouling.

(*d*) *Air-Supply Line for Air-Line Respirators.*

(1) The hose and couplings shall be placed under an internal air pressure of twice the maximum operating pressure specified by the manufacturer or at least 25 lb per sq in. (1.75 kg per sq cm) whichever is the greater value. The hose shall show no signs of rupture or separation from the couplings.

(2) *Tightness.*—Hose and couplings when submerged in water and placed under an internal air pressure of two times the maximum pressure specified by the manufacturer or 25 lb per sq in. (1.75 kg per sq cm) whichever is larger, shall not permit leakage greater than 0.61 cu in. (10 ml) per min at each coupling.

(3) *Kinkability.*—A 25-ft (7.6-m) length of the hose shall be placed on a table and shaped into a one-loop coil with one end connected to an air-flow meter supplied with air at a pressure equivalent to a 10-in (25.4-cm) column of water. The hose connection shall be in the plane of the loop. The other end of the hose shall be pulled tangentially to the loop and in the plane of the loop until the hose takes the form of a straight line.

To meet the requirements of the test the loop shall maintain a uniform nearly circular shape and ultimately unfold as a spiral, without any localized deformation that would decrease the flow of air to less than 90 percent of the flow when the hose is tested as a straight section.

(*e*) *Direct Leakage and Man Test.*—Tests for fit to the physical contour of the face shall be made by three men having different facial contours to assure that the device may be worn without discomfort and without leakage of dust or gas to the inside of the device. See 155 (*h*).

Tests of air-line respirators shall be made with the air supply adjusted to give the minimum required for maintaining a positive pressure in the facepiece, and also with the adjustment in the wide-open position.

158. Tests for Gas Masks and Canisters.

Except as otherwise specified, tests will be made at 20° to 25° C (68° to 77° F) with air having a relative humidity of 50 percent.

(*a*) *Specific Gas.*—A specified gas in the same concentration as that in which the gas mask is to be used shall be passed through the canister at the rate of 1.13 cu ft (32 liters) per min for 20 min and the issuing air at any time during the run shall contain not more than 5 parts per million of the specified gas.

With double the above concentration and doubled rate of flow, the issuing air shall not exceed the above value at the end of 5 min.

(*b*) *Organic Vapors.*—The vapor of carbon tetrachloride in concentration of 5,000 parts per million parts of air, by volume, passed through the canister at the rate of 1.13 cu ft (32 liters) per min for 30 min, shall be so completely absorbed that the air which passes through the canister at any time during the run shall contain not more than 5 parts per million of the carbon tetrachloride.

With double the above concentration and doubled rate of flow, the issuing air shall not exceed the above value at the end of 5 min.

(*c*) *Acid Gases.*—When chlorine, hydrogen cyanide, or sulfur dioxide, in concentration of 5,000 parts per million parts of air, by volume, is passed through the canister for 30 min at a rate of 1.13 cu ft (32 liters) per min the issuing air at any time during the run shall contain not more than 5 parts per million of the gas used.

With double the above concentration and doubled rate of flow, the issuing air shall not exceed the above value at the end of 5 min.

(*d*) *Ammonia.*—When ammonia gas in concentration of 20,000 parts per million of air, by volume, is passed through the canister at a rate of 1.13 cu ft (32 liters) per min for 20 min, the issuing air at any time during the run shall contain not more than 100 parts of ammonia per 1,000,000 parts of air.

With half the above concentration and doubled rate of flow, the issuing air shall not exceed the above value at the end of 5 min.

(*e*) *Carbon Monoxide* (*Class 1*).—When carbon monoxide in concentration of 10,000 parts per million of air by volume is passed through the canister at the rate of 1.13 cu ft (32 liters) per min for 4 hr, the issuing air during the entire period shall contain not more than 58.6 cu in (960 ml) of carbon monoxide.

With the above concentration and a rate of flow of 2.26 cu ft (64 liters) per min for 15 min, the issuing air shall contain a total amount of carbon monoxide not exceeding 58.6 cu in (960 ml).

With a concentration of 5,000 parts per million, a temperature of 0° C (32° F), relative humidity of 100 percent, and rate of flow of 1.13 cu ft (32 liters) per min for 1 hr, the issuing air shall contain not more than 58.6 cu in (960 ml) of carbon monoxide.

(*f*) *Carbon Monoxide* (*Class 2*).—When carbon monoxide in concentration of 10,000 parts per million of air, by volume, is passed through the canister for 1 hr at the rate of 1.13 cu ft (32 liters) per min, the issuing air during the entire period shall contain not more than 39 cu in (640 ml) of carbon monoxide.

With a concentration of 5,000 parts per million, a temperature of 0° C (32° F), relative humidity of 100 percent, and same rate of flow for a period of 30 min, the issuing air shall contain a total of not more than 39 cu in (640 ml) of carbon monoxide.

(*g*) *Chemical Stability*.—A stream of air at temperature of 22° to 26° C (71.6° to 78.8° F), 25-percent relative humidity, and free from carbon dioxide shall be passed through a canister for 6 hr at the rate of 2.26 cu ft (64 liters) per min. The canister shall then meet the test specified in the first paragraph of (*a*), (*b*), or (*c*) above, respectively, modified as to duration to 10 min.

A stream of air at temperature of 22° to 26° C (71.6° to 78.8° F) and 85-percent relative humidity, and free from carbon dioxide, shall be passed through a canister for 6 hr at the rate of 2.26 cu ft (64 liters) per min. The canister

shall then meet the test specified in the first paragraph of (*a*), (*b*), or (*c*) above, respectively, modified as to duration to 10 min.

(*h*) *Smoke, Dust, and Mist.*—If a gas-mask canister is designed to give protection against smokes, dusts, and mists in combination with gases and/or vapors, it shall meet the following additional requirements:

The filter shall retain at least 95 percent of the passing tobacco smoke at the end of a 5-min period when tested on a smoke-testing apparatus under the following conditions: Fume used, tobacco smoke; rate of flow of gas, 3 cu ft (85 liters) per min; length of test, 5 min.

(*i*) *Man-Tests.*—The final criterion for judging a gas mask shall be the protection afforded by the complete mask when worn by men. The mask shall be capable of giving complete respiratory protection for a period of 30 min when worn by men breathing the maximum concentration of gas or gases for which the mask is to be used.

159. Tests for Oxygen Breathing Apparatus.

NOTE.—In carrying out the tests specified in this rule, the details given in Schedule 13B of the United States Bureau of Mines shall be followed.

(*a*) *General Description of Tests.*—The working period of the tests shall be the time rating of the apparatus. The temperature of the inspired air shall not exceed 110° F (43.3° C) when that of the external air is not above 85° F (29.4° C). Temperature readings shall be taken at regular intervals.

A single test shall be continuous, without removal of the apparatus from the wearer during the test.

The apparatus under test shall be worn by a person during each of the tests, which shall be conducted in a specially equipped gallery filled with an irrespirable atmosphere.

160. Tests for Hats or Caps.

(*a*) *Moistening.*—Before applying the tests in paragraphs (*b*) and (*c*), the cap or hat shall be subjected in normal position to water from a sprinkler for 2 min.

(*b*) *Mechanical Strength.*—When mounted on a wood block similar in shape and position to a man's head, the crown of a protective hat or cap shall withstand the impact of an 8-lb (3.6-kg) iron ball (diameter approximately 3.8 in =9.6 cm) dropped from a height of 5 ft (1.52 m) without breaking or denting sufficiently to touch the wood block. The cradle shall withstand the blow without breaking or permitting the hat or cap to be forced down on the block.

(*c*) *Electrical Test.*—Protective hats or caps used in mining shall withstand without breakdown an application of 2,200 v, 60 c/s, for 1 min between any point of the crown and the inside of the cradle.

86095°—38——4

DISCUSSION OF THE RULES

SECTION 1. GENERAL REQUIREMENTS

The need for definite requirements to protect the eyes of industrial workers is well illustrated by the statistics of accidents and compensation in those states where full accident reports are regularly made. In Wisconsin in 4 years prior to the depression there were 2,767 cases of industrial eye injuries, of which 147 involved both eyes of the worker. Two cases resulted in death, four in permanent total blindness, and 579 in permanent partial disability. Total compensation awarded was $1,266,450, in addition to which medical fees aggregated $182,943. In Pennsylvania in 3 years there were 1,771 eyes lost, and the Department of Labor and Industry stated in 1923:

> In the ten years' experience of this Department in accident prevention, there is not a single example of loss of sight from flying particles of material when goggles were worn, even if the goggles were broken when struck by flying particles.

In New York State in 1 year 349 workers lost the sight of one eye and 363 suffered a permanent partial injury. $1,300,000 was awarded in compensation in that year.

A survey carried out in 1926 and 1927 by the National Society for the Prevention of Blindness and the National Safety Council indicates the great saving of eyes due to the wearing of goggles. In 583 industrial plants, it was reported that a total of 7,411 employees had their eyes saved by wearing goggles, out of a total of 578,000 employees. This represents an eye for each 156 employees each year. The industries covered included metal working, mining, foundries, chemicals, quarrying, etc. This report also shows that approximately 200,000 eye accidents occur in industry annually and that, except for fatal accidents, they surpass all other kinds in seriousness and expense.

A Pittsburgh steel corporation employing 8,000 men reported that the use of goggles prevented 20 to 25 cases of possible loss of vision annually, with a direct saving of $50,000 to $60,000 a year in compensation.

Eye accidents reported are almost entirely of a mechanical nature and include very few cases of a pathological nature. This is partly due to the fact that it is not only hazardous, but uncomfortable and inconvenient as well, to expose the eye to dangerous sources of light. Goggles or helmets are almost invariably used in welding work, but even where injury to the eye results from such exposure, the effect is not instantaneous and sensational; no notice of it may be taken by a workman's companions, no first aid is extended, and perhaps no report is made. If the injury is not severe, the eye will recover, so that the damage is not permanent and probably no claim for compensation is made.

The mechanical hazards to the eye in a particular shop are too frequently permitted to go without attention until an accident occurs. Even in shops where goggles are provided, workmen frequently go unprotected. For this reason, although shops providing goggles are likely to have a lower rate of eye injury than others, injuries will not be entirely wiped out until the use of protectors in hazardous processes becomes universal.

Eye injuries occur almost invariably to men who fail to wear protectors, making the need of special attention to this subject by shop superintendents, perhaps with the additional incentive of legal compulsion, very urgent. It is very rare indeed for a workman wearing goggles to lose an eye, although it has happened that a blow on the eye was so severe that no available goggles would give protection. It is not possible to protect at all times against such unusual conditions, but the rules and strength tests have been devised to give protection under ordinary working conditions. The great problem is to get the workers to wear the protectors which are supplied. Sometimes the protectors are not comfortable; sometimes the worker forgets; sometimes he thinks it will never happen to *him*.

It is very salutary to display in the shop broken goggles which have saved some worker's eye. It is helpful to display reminders in the form of posters or placards.

In one shop an electric sign "Wear Your Goggles" is flashed on when the grinding-wheel motor is started. In another a small card with the same admonition is attached to portable riveting hammers, air drills, cold chisels, etc. Where broken goggle lenses are displayed it is generally well to give the name of the wearer, particularly in small or moderate-sized plants. In large plants the display could be made in the shop section or division where the accident occurred. Generally a workman whose eye is saved by goggles will be, for a considerable period at least, an excellent missionary for the use of goggles. Where a name is given it will lead to questioning of the wearer by other men in the shop and the fact that one of their coworkers has saved an eye is of considerable value in securing compliance with regulations for the use of such protectors.

Devices which have been subjected to examination by some properly qualified body and found to comply with the general requirements of this code should be used in preference to others which have not been so examined. To avoid the necessity for repetition of such examination by different examiners, frequently with inadequate facilities for such work, and to avoid the confusion which would result from conflicting reports as to the suitability of devices examined for a given purpose, it is desirable that such examinations should be made under standard conditions by organizations properly equipped and qualified for experimental testing and inspection of the run of goods at the manufacturers' plants, and the record made generally available.

The scope of this edition of the code has been extended to include protection to the lungs and respiratory tract. By protection is meant the exclusion of noxious gases and fumes and of dust in such forms or quantities as will be injurious to the workers. To determine quantities that will be injurious is not easy, as appropriate limits of tolerance are not yet known for some forms of dust which may be encountered in industry.

10. Scope, Application, and Compliance.

The scope of these rules is confined to industrial operations. Valuable guidance will be found for protection in other occupations, military, naval, sporting, etc., such as military expeditions over snow-covered ground. Aviation is now an established transportation industry and no longer mainly a military occupation or sport. Eye protectors are needed for pilots, and these are usually of special design but will come under classification *C*, the requirements for which are not difficult to meet.

It is obvious that those operations which provide their own protection from flying particles or from other possible source of injury should not be hampered by the requirement that protectors be worn in addition. Examples of such equipment are a grinding wheel with a glass shield interposed between the wheel and the operator's eyes, and the sand-blast cabinet arranged for the operator to control the operation from outside.

It is obviously better to remove the hazard, when this is possible, than to protect the worker against it. Thus, in granite cutting it is preferable to remove the dust by an exhaust system rather than to allow it to contaminate the air, and then to protect the worker against breathing the dust. This is similarly true of rock drilling, for which wetting the material is an alternative to exhausting the dust. In operations involving toxic gases or fumes, totally inclosed equipment may enable the air in the working area to be maintained at a tolerable, low concentration of the gas or fume. This code does not attempt to specify how various industries shall be conducted, with respect to avoiding hazards, but points out the method of protecting the worker where the hazard has not been eliminated by such other means.

Operations can be divided into two general classes, namely, those where it is essential that the workers wear proper protectors, and those where it is optional with the workers to wear protectors. Examples of the first class are chipping metal and arc welding. Examples of the second class are automobile driving and exposure to glare.

Obviously, it is necessary that a proper supply of protectors be kept on hand in both cases. In the first class, the employer should feel it incumbent upon him to so organize his work in all departments as to require workers to wear the proper protectors, and not depend on the worker to judge whether protectors are necessary. On the other hand, the hazard involved in such occupations as automobile driving is not great except under severe weather conditions. The worker recognizes the necessity for protection in these cases, since without the use of protectors physical discomfort ensues. He may be expected accordingly to request proper protectors, particularly if it is well understood that it is the established policy to furnish them on request.

Specific concentrations of toxic substances which constitute a hazard to health are a matter of much uncertainty. Small quantities of some toxic substances can be breathed with impunity, the amount depending upon the length of time such substance continues to be breathed. For some materials, such as lead dust, the toxic effect is cumulative, and hence the concentration of such materials in the atmosphere must be comparatively low, if the atmosphere is to be breathed continuously without harmful effects. Extensive researches have been conducted with some toxic substances, and experiments have been made upon animals, from which the results with human beings are inferred. The susceptibility of different individuals, however, is not even approximately the same.

New materials are frequently introduced in industry with little knowledge of their toxic properties, so that questions as to the concentrations of many materials in air which are hazardous cannot be answered at the present time. In attempting to answer such questions it must be kept in mind that the limiting concentration which can be considered tolerable will depend upon the length of exposure and the frequency of repetition. In attempting to fix values for industrial guidance, one naturally assumes exposure for the working day, day after day.

Of the nonmetallic dusts, quartz is one of the most hazardous and has been long known to produce silicosis. Microscopic particles below 10 microns in size are known to be

most injurious, and when these particles are in the form of granite, investigation has again furnished a limit of tolerance, this limit depending of course upon the time of exposure. It is probable that the amount of quartz in the dust is generally a controlling factor but there are exceptions. However, it seems reasonable to limit quartz-containing and other siliceous dusts to quantities no greater than the limit of tolerance for granite dust, and to even less in the case of materials that contain 75 to 100 percent of quartz. Granite contains approximately 35 percent of quartz.

Some industrial dusts, such as bituminous coal, marble, and many organic materials, have not been observed to produce injurious effects similar to quartz, and it is not known in what concentrations they become injurious; but an excess of any dust may prove suffocating to the worker. Some, such as asbestos dust, are known to produce permanent injury, but limits of tolerance have not been established. Where such dusts are known to be present, they should either be so exhausted as not to contaminate the atmosphere, or the worker should be provided with a suitable respirator or mask.

Another complication arises from the possibility that one atmospheric contaminant may modify the toxic effect of another atmospheric contaminant, and instances are already known where such a result has been found. Knowledge of such effects is at present too restricted to be of general application.

In 1935, the American Standards Association set up a National Advisory Committee on Toxic Dusts and Gases for the purpose of collecting and making available the best information on this subject, but recommendations from that committee are not yet available. As sources of information on the subject, reference may be made, however, to the following publications.

Y. Henderson and H. W. Haggard, Noxious Gases, Monograph 35 of American Chemical Society.

R. R. Sayers and J. M. Dallavalle, Prevention of Occupational Diseases, Mechanical Engineering, volume 57, page 230 (1935).

Ethel Browning, Toxicity of Industrial Organic Solvents, Report No. 80 of Industrial Health Research Board, London.

United States Public Health Service Bulletin 236.

F. Flury and F. Zernick, Schädliche Gase, Berlin (1931).

William D. McNally, Toxicology (1938).

Health Practices Pamphlet No. 4, Dust, National Safety Council.

United States Bureau of Mines Information Circulars, Review of Literature on Effects of Breathing Dusts.

T. Solomon, A Manual of Pharmacology and its Application to Therapeutics and Toxicology (1932).

The above are summaries of results found by various researchers, no attempt being made to give here references to original sources, many of which deal with only a single substance.

Attention has been given to maximum allowable concentration of atmospheric contaminants to which industrial workers may be subjected by several state regulatory bodies, and such values will be found in publications of the California Industrial Accident Commission, Connecticut Department of Health, Massachusetts Department of Labor and Industries, and Wisconsin Industrial Commission, as well as in some of the references above given.

In view of the uncertainty as to the specific values applicable to an individual case, the engineer or physician responsible for conditions will attempt to supply air which allows a substantial margin of safety from the hygienic standpoint, having in mind clean country air as an ideal to be approached as nearly as practical considerations will allow; and will arrange for the use of protective equipment whenever and wherever such a margin of safety is not found to be feasible.

It seems reasonable to set a limit for any type of dust at 50,000,000 particles per cu ft, as measured by the impinger method (see Greenburg and Bloomfield, Public Health Reports 47, p. 654 (1932).

11. Classification of Operations and Processes.

The use of goggles and other protectors in industries where processes are carried on which involve hazard to the head and eyes, is widespread, especially in works such as

the steel plants, which have long had organized safety. The operations and processes which are so hazardous as to make it desirable for workmen to be provided with special protection to the head and eyes are varied. Therefore no attempt has been made to name the specific operations or processes against which protection should be given, but rather an attempt has been made to classify the character of the hazards which are existent in industry, leaving it to the employer, or the administrative authority, or other responsible party to assign the particular operation concerned to its proper group.

The various operations and processes which require protection to the head, eyes, and lungs have been classified into twelve groups according to the degree and nature of the hazard involved. Different hazards require protectors having distinctive features.

The hazards from flying solid particles ordinarily encountered are separated into three groups designated *A*, *B*, and *C*. Group *A* includes all operations wherein the mechanical hazard is so great as to warrant the selection of protectors the parts of which have passed mechanical tests assuring adequate strength. Group *B* embraces all operations in which the protector must prevent the entrance of small flying particles into the eye. The lens will not be subjected to severe blows and hence no mechanical tests are necessary. While strength of the frames of goggles used for this purpose is not a prime requisite, definite requirements for the material entering into their construction is necessary. Hence a separate group for these processes has been made. In group *C*, which includes occupations similar to automobile driving, protectors are used merely to keep small foreign particles out of the eyes, and hence the protector need not withstand any special strength tests.

In processes where splashing metal is used the special hazard is from burns from molten metal which might be projected with force. The degree of hazard varies with the operations and therefore a number of different methods of protection are suitable. Workers handling fumes, gases, and liquids require protectors of various designs, each one having protective qualities peculiarly fitted for the work.

These operations have accordingly also been classed in a separate group.

In the next three groups are classified all of the operations in which the worker is exposed to harmful radiant energy. Definite limits to the transmission of the radiant energy through the lens or window of the protector have been set. These limits are based on the degree of hazard involved, an analysis of which results in the assignment of the hazard to one of the three groups.

The hazards incident to abrasive blasting are not met in any other process, hence this operation is treated as a separate group.

Protection to the lungs and respiratory passages in other operations is classified in two groups—one dealing with gases and vapors, the other with solid and liquid particles however small they may be. The latter can be intercepted by a mechanical filter, whereas the former must be absorbed or chemically acted upon. The respirator is more commonly used for solid particles and the gas mask for noxious gases. Finely divided liquids in suspension in the air in the form of fog or fumes are classified with the solids, as they can be trapped by a filter.

A hose mask or air-line respirator furnishing uncontaminated air from an outside source is, of course, an alternative in many cases to either of the above, but is indicated for work in a stationary location. Oxygen breathing apparatus is an alternative for more extended operations, as in a gaseous coal mine, where it has been principally used, but is suitable for use only by trained men.

Some operations call for protection of both types *I* and *K*, such as the spraying of paint or lacquer containing benzol and siliceous material. A hose mask gives the necessary protection, but where this is not feasible, use may be made of a chemical-filter respirator in which a mechanical filter is provided also. Such a protector must meet the requirements for both types of protection.

Another new group has been introduced in this edition to deal with head protection, for which definite specifications are now given.

Where women workers are employed in shops, their hair should always be protected from dust and from the danger of catching in machinery by light weight, comfortable caps which may be made of cambric or glazed muslin. Under no circumstances should girls be allowed to work near machinery with the hair streaming or fluffed out several inches from the head. Head covering is equally necessary for fire protection where flammable vapors or gases are present.

If women are engaged in light bench operations with motor-driven apparatus, it is desirable to have the apparatus driven by a motor or line shaft under the bench, rather than overhead.

In the accompanying table are summarized the groups of operations and the types of protective device suitable for each. There are some operations which involve hazards appearing in more than one group, and in such cases there must be selected one or more protective devices whose combined functions will give the necessary protection. Thus a respirator and goggles may both be necessary; in some electric-welding operations both helmet and respirator may be called for; a mechanical filter may be included in a gas-mask canister to cover group *I* as well as group *K*. This summary may assist one in making a general survey of the available types of equipment and their general application.

12. Definitions.

Under this rule are defined such terms for the designation of protective devices as may be necessary to distinguish the types of protector designated in the several rules. In general, the intention has been to define these terms in relation to the purpose to be attained rather than with respect to design features. The terms "hood" and "helmet" have sometimes been used rather loosely and indiscriminately. The distinction is here made on the basis of rigidity, the hood being usually made of fabric and the helmet of some stiff material, such as fiber-board or wire gauze. The helmet does not necessarily completely cover the head, whereas the hood does.

CLASSIFICATION OF HAZARDS AND PROTECTIVE DEVICES

Group	Hazard involved	Part to be protected	Permissible protective devices
A	Relatively large flying objects.	Eyes	Goggles, face mask, or helmet.
B	Dust and small flying particles.	do	Goggles.
C	Dust and wind	do	Do.
D	Splashing metal	do	Face mask or goggles.
E	Gases, fumes, and liquids.	do	Goggles, face mask, hood.
F	Reflected light or glare.	do	Goggles.
G	Injurious radiant energy (moderate).	Eyes	Goggles, face mask, helmet, or shield.
H	Injurious radiant energy (intense).	Eyes and head	Helmet or shield.
I	Dust, smoke, mists, or fumes.	Respiratory organs.	Respirator, hose mask, or oxygen breathing apparatus.
J	Excessive amounts of dust and small flying particles.	Eyes, head, and respiratory organs.	Hood or helmet with fresh-air supply.
K	Noxious gases or vapors.	Respiratory organs.	Gas mask, hose mask, respirator, or oxygen breathing apparatus.
L	Falling objects	Head	Hat or cap.

13. Classification of Protectors.

The types of protectors in use vary in shape and construction according to the use for which they are designed. For use in certain operations protection to the head is required, whereas in others protection to the eye is all that is required. The designs of protectors which may be used to mitigate the hazards incident to a process or operation are varied. To insure adequate strength regardless of the design, certain strength tests are prescribed in the rules for protectors which might be subjected to severe blows, namely, those included in

groups *A* and *L*. For the purpose of distinguishing between the different forms and shapes of goggles, they have been classified according to design and a style number assigned to each class. This designation has no reference to strength or ability to meet tests. This avoids confusion when referring to the style of goggles whose use is permitted for a given kind of work and in differentiating between the tests to be applied to them.

14. Lenses for Persons Having Defective Vision.

There is a difference of opinion among safety engineers as to the best method to pursue to give employees who have defective eyesight proper protection when their work is such that it could be properly classified in the groups mentioned in rule 11. There is general agreement that the spectacles the worker ordinarily wears do not give sufficient protection, at least for most of the groups. Goggles should be furnished and worn over the spectacles, or else the lenses of the goggles should be ground to provide the proper optical correction.

15. Replacement of Lenses.

Some employers prefer to use goggles of such a design that the lenses are permanently and securely held in the frame and are not replaceable except by the employment of special means. Broken goggles are allowed to accumulate, the ones broken being replaced by new goggles, until a large order can be sent to the manufacturer for replacement of lenses.

On the other hand, other employers prefer to replace their own lenses, in which case it is desirable that this may be easily done in order to discourage the retention in service of broken goggles. Goggles whose lenses may be replaced merely by unscrewing a portion of the lens container, by the proper manipulation of specially constructed parts of the frame, or by the use of a tool generally available, such as a screw driver, are suitable. To prevent the unintentional replacement of an unsuitable lens, lenses which meet special requirements must be marked (see rules 21 (*a*), 92 (*c*)).

It is desirable that lenses and lens containers of goggles designed for a given operation be made uniform as to dimen-

sions so that they may be readily interchanged or replaced. Some manufacturers prefer to use a specially designed size or shape for processes involving hazards of one degree and a different size or shape for hazards of another degree.

16. General Requirements for Glass.

In this rule are grouped all of the general requirements for glass which apply to lenses and windows regardless of the processes in which employed, and whether they be used for mechanical protection or where radiant energy must be intercepted.

Glass having optical imperfections may distort the image or may cause eye strain and discomfort in the endeavor to focus properly the object viewed. A prism effect displaces the image slightly, and if this effect is the same for both eyes it is not nearly so serious as where the displacement is different (or even opposite) for the two eyes. Hence the requirement for parallelism is much more stringent for lenses covering a single eye than for windows covering both eyes. Defects of this nature are just as objectionable in a cover glass as in a filter glass, and hence both are required to meet the same standards.

There is no uniformity among manufacturers of goggles as to size or shape of lenses. It seemed justifiable to place a minimum on the sizes of lenses since an adequate field of vision is necessary. In certain operations it may be desirable to exceed these dimensions, particularly if the protector is placed at a greater distance from the eye than is contemplated in the use of the goggle.

SECTION 2. PROTECTORS FOR CHIPPING, RIVETING, CALKING, ETC.

20. Styles Permitted.

Goggles used in such operations as chipping and riveting may be subjected to blows directed from any position in front of the operator. This makes it necessary for chippers' goggles to give side protection. This may of course be accomplished by using side shields or the eyecup style of goggle.

Objection has been made to styles 2 and 3 for work where side vision is important, and a modification of this rule has been introduced on that account. For such work as sledging in quarries and foundry work, side shields may be dispensed with if a larger lens is used. This is a radical departure from previous practice which had already been tried out in Pennsylvania. While it is recognized that complete protection is not afforded by goggles of style 1, reports indicate that they are worn more conscientiously, so that in the long run greater protection is afforded. Goggles with side shields or eyecups are more effective when worn, but in certain work the men will not wear them except under compulsion.

21. Specifications and Tests for Lenses.

A high percentage transmission of light is of importance for this class of work. Almost any lens made of so-called "colorless" glass will transmit more than 80 percent of the incident light. Laminated lenses consisting of two glass elements held together by a layer of other material may not have transmission quite so high, so that the limit has been placed at 70 percent. The latter may become cloudy or may darken when subjected to heat, depending on the material which is used between the glasses and the method of sealing the joints. These should not be used when working in processes where they might be subjected to high temperature. Sterilization in hot water may similarly result in deterioration. Before such deterioration has become so pronounced as to interfere with vision the transmission will have diminished to a value less than 70 percent and this rule will consequently bar such lenses from use.

Lenses for chippers' goggles must withstand certain strength tests. In order to identify them properly it is desirable therefore that they be plainly marked.

The relatively severe blows to which chippers' goggles are likely to be subjected, and should therefore be required to withstand, makes it necessary to prescribe a strength requirement for protectors used in operations involving this hazard. The requirement is of the nature of a mechanical test to which a certain portion of the goggles to be used for this

service are subjected. A discussion of the test is given under rule 153. It has been found that repeated blows alter the character of glass, making it more liable to fracture. Hence a tested lens or one which has received a severe blow in service may not be as strong as it was originally.

22. Goggles of Style 2.

Side shields are necessary in order that flying particles can not enter the spaces around the lens container. They may, of course, be solid or perforated but, if perforated, the holes should not be large enough to allow particles to enter. The frames of goggles should be of light substantial material. The principal requirements are comfort to the wearer and strength enough to withstand the service. This service requirement is determined by a strength test of the lens containers and the frames.

24. Test for Frames.

The test for the lens containers is such as to insure the retention of the parts of the lenses, in case of breakage, in the container. The container should, therefore, withstand without deformation the drop test for lenses. In order to insure a reasonable life and strength of frames, which when subjected to severe blows will not be distorted unduly, it is necessary to prescribe certain tests for frames which are minimum requirements. These tests are different for the different styles of goggles. A further discussion of the test for frames is given under rule 151.

Frames should be made of a material that will withstand sterilization. Sterilization is necessary because there may be interchange of goggles among employees. The material should be such that it will not react chemically with the perspiration from the skin. Such action, if it occurred, might cause irritation or discoloration. For the same reason the material should not readily corrode. Discoloring of the skin is objectionable to the worker and should be avoided.

The corrosion test has been restricted to such frames as have the metal in actual contact with the skin. Aluminum has been used to a considerable extent for frames and is entirely satisfactory when separated from contact with the

skin by padding. It can not be expected to meet the severe test for corrosion specified in rule 152. The more readily corrodible metals such as steel are prohibited in rules 22 and 23.

The manner by which goggles are retained before the eyes is not of primary importance. Comfort is important, as this largely determines whether or not the goggles will be worn willingly by the workers, and unless worn willingly there will be great difficulty in securing their general use, and hence the necessary protection against accidents and loss of eyesight.

SECTION 3. PROTECTORS FOR SCALING, GRINDING, ETC.

The goggles used for scaling and grinding are not subjected to severe blows. The lenses serve merely to keep small particles which are thrown off during the course of the work from entering the eye. Hence, no strength tests are necessary. It is the practice of some shops to use the same style of goggles for grinding and scaling as for chipping, especially where the two operations are carried on by the same men or in the same shop. This is a good practice because it avoids the danger involved in the interchange of protectors between workers using grinder's goggles and those using chippers' goggles. With two kinds of goggles some hazard is incurred; but as this may be overcome by proper supervision, it is not considered necessary to require all grinders to wear the heavier goggles which meet the strength test prescribed for chippers' goggles in rule 21 (*b*).

Particles may be directed at an angle to the line of sight, and for this reason it is desirable to use lenses whose dimensions are at least equal to the minimum specified in rule 16. Side shields give slightly greater protection but a wide range of vision is desirable, and workmen who prefer to wear goggles without side shields should be allowed to do so.

SECTION 4. PROTECTORS FOR GROUP *C*

The hazard from exposure to dust and wind is not great. The chief considerations are that goggles should be comfortable and light in weight. There is danger of particles

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directed from an angle entering the eye, hence it is not desirable to waive the minimum requirement for size of lenses.

In aviation work it is customary to use special designs of goggle that give a wide angle of vision. Any form satisfactory to the wearer will meet all necessary requirements.

SECTION 5. PROTECTORS FOR BABBITTING, ETC.

50. Styles.

The nature of the operation largely determines which style of protector should be used. If there is a probability of water being present, the danger of the molten metal exploding is great and hence protection to the face as well as the eyes is needed. It is desirable in this case to use the face mask. Protectors giving at least the degree of protection afforded by goggles should be used in all other cases to protect the eyes from splashing metal.

51. Specifications for Masks.

It is not desirable to restrict the kind of material to be used for face masks or the designs to definite types. A variety of material is available for making masks to accomplish the purpose.

52. Specifications for Goggle Frames.

Tests conducted by manufacturers and by the National Bureau of Standards demonstrate that the principal cause for failure of goggles is the heat of the molten metal and not the impact of the explosion. The test consisted of dropping 5 g of molten lead from different heights on a number of lenses of different makes. It was found that in no case was the goggle frame injured, the damage being confined to cracking of the lens. With these facts in mind it is not necessary to specify a strength test for the frames. The design of the lens container should be such, however, that in case a lens cracks the fragments will be retained in position in the container. This prevents injury to the eye from flying glass.

53. Specifications for Lenses.

As stated above, a molten-metal drop test on a large number of lenses showed that the heat of the metal and not the impact is the important element in the test. It was found

that for glass of a given make the thickness of the lens determines to some extent at least the resistance to cracking when molten metal is poured on the surface of the lens.

It was therefore concluded that protection will be afforded by a lens that will withstand a moderate blow of molten metal, and a lens container that will retain a cracked lens in position. The former is sufficiently assured by placing a minimum limit for the thickness of glass.

The need of unimpaired vision in the pouring of molten metal is apparent. This is the reason for specifying a minimum light transmission. Almost any lens made of so-called "colorless" glass will transmit 70 percent of incident light. (See also the discussion under rule 21.)

SECTION 6. PROTECTORS FOR HANDLING CORROSIVE CHEMICALS, DIPPING, BRUSH COATING, ETC.

60. Styles.

The nature of the process for which protection is furnished when handling acids, caustics, fumes, and other corrosive or poisonous chemicals, determines to a great extent the type of protector to use. The operations are so varied that it is not deemed advisable to prescribe in detail the type of protector to be used. Judgment and experience must determine this.

If noxious gases are involved also, see group *K*.

61. Specifications for Goggles.

Goggles which do not fit the configuration of the face should not be used. In order to avoid splashing liquids coming in contact with the eyes it is desirable to use eyecups, which fit closely but which are provided with ventilating openings at side covered in such manner as to prevent the entrance of liquid into the eye. This arrangement will afford a means for escape of the vapor arising from perspiration which would otherwise condense on the lenses and obscure vision. Even the provision of ventilating openings will not obviate the condensation altogether. In those cases where the presence of fumes would undesirably affect the tissues or would irritate the eyes or nostrils, ventilation should not be provided.

Condensation of vapor on the inner surface of the goggle lens may be avoided by the application of glycerine or special waxes to the surface. Another method of avoiding condensation is the use in some goggles of a double window; that is, inside of the protective glass there is another thin glass with an air space between.

62. Specifications for Face Masks.

In processes where the operator is exposed to splashing or projection of large amounts of acids or caustics into his face it is desirable to protect the entire face or even the entire head, as well as the eyes. A variety of material is available for making masks and hoods to accomplish the purpose, the design being such that there are no openings in the mask through which chemicals might pass.

63. Specifications for Hoods.

When working in gases which affect the mucous membrane or skin, hoods which cover the head and neck must be used. Each process requires special attention. Therefore no detailed specification for the type of hood required can be made. Mitigation of the hazards in these processes is perhaps more in the province of the sanitary engineer and physician, since the health more than the safety of the operator is involved.

64. Specifications for Lenses.

Protectors for these processes are not likely to be subjected to severe mechanical shocks, and for this reason no strength tests are necessary. The material of which the lens is made should be given consideration before the protector is put in use. For example, the chemicals used in the frosting of glass (such as lamp bulbs) undesirably affect the glass, and hence in handling such substances other material such as cellulose acetate or methylmethacrylate (a synthetic resin) must be used for the lens. Flammable materials, such as cellulose nitrate, should be avoided.

SECTION 7. PROTECTORS FOR EXPOSURE TO GLARE

The style of goggle to be used for protection against sunlight reflected from snow and similar sources of glare is of no particular moment. The reduction of the intensity of radia-

tion entering the eye is the end to be accomplished. Since this can be done by the provision of a large lens, the use of side shields should be left to the discretion of the wearer, as should also the density and tint of the colored glass used in the lenses. If used, side shields should be of dark material so as not to reflect much light.

SECTION 8. PROTECTORS FOR OXYACETYLENE WELDING AND FURNACE WORK

The style of protector to be used depends on the amount and nature of the work to be done. The more serious hazard of the process is the pathological effect on the eyes which is produced by the radiant energy from the light source. A hazard of lesser degree is small flying masses of molten metal. Manufacturing limitations and hard usage limit the minimum thickness which can be used. This limit of thickness is high enough to offer protection against flying particles. The protectors need not, therefore, meet any strength tests. The design should be such that no unfiltered radiant energy is allowed to enter the eye. For this reason it is desirable for operators to wear goggles of style 3 (with eyecups), face masks, or helmets, whenever two or more operators work in close proximity.

The heat radiated from the work is so great that unless the parts of the protectors which touch the face are made of heat-insulating material the operator will experience considerable discomfort, which will tempt him to discard the protectors. The use of heat-insulating material is therefore required.

85. Specifications and Tests for Protective Glass.

A discussion of the optical tests for oxyacetylene welder's glasses and the reasons therefor is given under rule 154.

The cobalt glass so commonly used by furnace men is not effective in providing protection from ultraviolet radiant energy. The judgment of many such men as to temperature and stage of reduction of a furnace charge has been developed while using such glass and may be dependent upon a continuation of its use. Moreover, inspection of the charge lasts but a few seconds at a time and consequently does not offer the

same hazard as continued exposure to such sources of light. It is consequently suggested that the use of such cobalt glass be permitted by those trained to work with it and who are responsible for judging heats, but that its use be gradually eliminated by educating the new men to judge the condition of the charge by the use of glass which will afford more perfect protection.

It is possible to make a glass which retains the color of cobalt glass but also excludes the dangerous ultraviolet rays. This is done by adding cerium oxide to the melt. For a detailed description see Coblentz and Finn, American Ceramic Society Journal, volume 1, page 423 (1926).

As required by rule 11, electric-resistance lap and butt welding, where a relatively large amount of radiant energy is encountered, are classified in the same group as oxyacetylene welding. The reasons for this classification are given in the discussion of the tests for lenses, rule 154.

Two-part lenses, the lower half colored and the upper half clear, are sometimes used, particularly when the work is intermittent and the operator's attention is frequently distracted from his work. When close attention to the work is required for considerable periods of time, protectors using entire colored lenses are preferable.

In order to be assured that lenses which are satisfactory may be duplicated by the user of protectors, it is desirable that the lenses be so marked that they may be identified.

For reasons of economy it is desirable that lenses be provided with cover glasses which on becoming pitted can be thrown away and new ones inserted. The life of the more expensive protective lens is thus lengthened.

SECTION 9. PROTECTORS FOR ELECTRIC-ARC WELDING AND CUTTING

90. Styles.

As in the case of oxyacetylene welding the hazard to be protected against is the intense radiant energy. In this case the ultraviolet radiation is so intense that serious burning of the skin as well as injury to the eyes may result from long exposure. It is therefore necessary to protect the face and head as well as the eye. The material from which the hel-

mets or shields are made must be opaque to ultraviolet and visible radiation.

91. Specifications for Protection.

The forms of protector approved for electric-arc welders are the helmet and the shield. Helmets are generally of one of two types, the type supported by the head and that supported by the shoulders. Either type is satisfactory if properly designed but support from the head appears to be more popular. Helmets and shields should be so shaped as to protect the entire face. Care should be taken that protection is afforded against the radiant energy from the arcs of other operators in the vicinity.

The design of helmets and shields is such that much better vision may be secured while the welding and cutting is being carried on by the use of a large single window than by the use of two separate lenses. This rule has been revised to permit the latter practice, however, by those who prefer it. An adequate range of vision is secured by the minimum dimensions for the windows specified in rule 92.

92. Windows.

A full discussion of the tests for arc-welders' windows and the reasons therefor is given under rule 154. The use of cover glasses has been discussed under rule 85.

The choice of the particular shade number of filter glass to be used for a particular operation is largely a personal matter and should be made from the standpoint of the comfort and ease of seeing of the person wearing the protector.

In the discussion of rule 154 (*c*) are given some suggestions as to the density of glass which will generally be found satisfactory for particular cases of welding.

93. Protection for Other Workers.

The protection of other workers who may be exposed to the radiation from an electric arc is accomplished by segregating the electric arc welders in a room separate from the others or by surrounding them with a suitable opaque inclosure. In no case should arc welding or cutting be done, if other workers are, or are liable to be, in the vicinity, unless this protection is provided.

If there is likelihood that ultraviolet light may reach any one's eyes by reflection from screens or the inner surfaces of shields or helmets, the reflecting surface may be coated with an absorbing paint, such as one made up of lampblack. The lampblack completely absorbs the ultraviolet.

SECTION 10. PROTECTORS FOR EXPOSURE TO DUST, FUMES, MISTS, SMOKES, OR OTHER ATMOSPHERIC PARTICULATE MATTER

101. Mechanical-Filter Respirator.

Three important qualities for a respirator to have are a good fit to avoid leakage of air, a high efficiency in filtering the foreign material out of the air, and a low resistance to air-flow, so as not to impede breathing. The second and third qualities can be determined by test of the respirator in the laboratory and such tests are described in rule 155.

Although the general features of facepiece design that pertain to fitting the face can be determined by laboratory trial on a selected group of persons with widely different facial contours, as prescribed in rule 114, the final question of fit and air leakage is one which involves the individual who wears the respirator, and cannot be settled once for all by a laboratory test. Respirators should be flexible enough to fit various facial contours, and a cushion of soft rubber along the edge is helpful, but some individuals cannot wear rubber continuously in contact with the skin, as the exudations from the skin may attack the rubber. If there is any doubt regarding leakage, a so-called "man test" can be made by sampling the air inside the respirator while it is in position on the wearer's face, and determining whether such air is suitable to be breathed. Contamination does not prove leakage from misfit, as it may be due to imperfect filtering, a leaky exhalation valve, or other cause.

No limitations are placed on the choice of material for the filter. Felt, cotton, flannel, paper, sponge, and cheesecloth have all been tried, with varying success. The area of cross section cannot be too restricted, or the resistance to inhalation will be too high. To meet the resistance limit for exhalation, an exhalation valve will usually be necessary.

Such an exhalation valve is commonly of the flutter type, as this has been found satisfactory for the purpose.

For temporary use, a very helpful respirator can be improvised on the spot by placing a wad of absorbent cotton in a piece of cheesecloth or muslin, and tying it in position over the nostrils by a strip of muslin running around the back of the head. Care must be exercised to leave no passage for air into the nostrils except through the cotton wadding. The material should be discarded after being used once.

Mechanical-filter respirators are classified with respect to their use for dusts, fumes, and mists. Owing to the small size of the particles, fumes or smokes are the most difficult types of particulate matter to arrest and require very dense filtering fabric. Fumes of various metals are produced in chemical and metallurgical processes by sublimation or by the condensation of vapors or from chemical reaction of vapors and gases. Many of these fumes are highly toxic.

Mists may be formed in the process of spray coating with paints, vitreous enamels, and glazes. Chromic acid mist is produced in chromium plating. In general, mists are of a particle size equal to or exceeding the common size of dusts, and filtering is no more difficult than for dusts.

Mechanical-filter respirators do not protect from gases and vapors. They should not be used in processes where an air-supply device is necessary to meet the hazards which are present.

102. Air-Line Respirator.

Air-line respirators have been found convenient where compressed air has been available for other purposes, as in spray painting and sandblasting. Such respirators were first developed to meet the conditions of such an air supply. It involves difficulties from the possible contamination of such supplies of air with objectionable and even harmful substances.

This type of respirator is acceptable in protecting workers from atmospheres that are not immediately dangerous to life but which may cause illness or occupational disease after prolonged exposure. This equipment usually involves a hose of small diameter through which a person cannot draw enough air by inhalation to meet bodily requirements, and

hence they may be dangerous if used in atmospheres from which the wearer could not escape without respiratory protection. For such locations the hose mask through which the wearer may breathe without having air supplied under pressure is considered preferable.

The air supply to an air-line respirator should not only be safe to breathe but free from objectionable odors and impurities, such as oil fumes, and the temperature and humidity should have values not incompatible with the wearer's comfort. Air supplied from air compressors may contain oil vapors, carbon monoxide gas, and other undesirable constituents. It is consequently important that the compressor intake is not in a region of contaminated air, that the lubricants used have a high thermal stability, and that the delivered air be passed through a trap or filter which will remove dirt, odors, oil, and excess moisture. If there is a possibility of carbon monoxide being formed, an indicator for this material may well be put in the delivery hose.

Since the direct expansion of high-pressure air into a respirator may chill it to a point where it is unpleasant or even unhealthful, heating appliances for warming the air have often been applied. Under some conditions of compressing and cooling the air the moisture is condensed and the humidity greatly reduced. The prolonged breathing of air which is too dry may be uncomfortable to the wearer, and under some circumstances it may be desirable to humidify the air.

The amount of air which it is necessary to supply the worker will depend upon the exertion which he is making and his individual lung capacity. This amount may vary from ¼ cu ft to more than 3 cu ft per min. In order that the pressure inside the respirator may never be less than the atmospheric pressure outside, it is desirable to have the airflow at least three times the average breathing rate since inspiration occupies only about one-third of the complete cycle of inspiration and expiration.

On the other hand, it is not desirable to have an excessive flow of air since this may result in chilling the face or head of the wearer. To meet the varying conditions it is desirable that the wearer have some control over the amount of flow so that it can be adjusted to the strenuousness of the work

and the condition of the weather. An excess air-flow in warm weather may be conducive to comfort, whereas in cold weather it might be objectionable.

103. Hose Masks.

The common type of hose mask was designed primarily for emergency and hazardous work in atmospheres having a deficiency of oxygen or containing gases whose inhalation for even a short period would be definitely harmful. It must, consequently, be possible to inhale through the hose even though the blower which may be attached at the supply end is not being operated. In such work it is usually desirable to have an assistant in the vicinity and a manually operated blower is consequently indicated. For situations other than the above, an electric-motor-driven blower may be convenient and entirely satisfactory.

SECTION 11. PROTECTORS FOR ABRASIVE BLASTING

The hazard to which operators in sandblasting operations are exposed is the inhalation of large quantities of dust over a considerable period of time. Hazards of smaller degree are injury to the eyes and abrasion of the skin by small flying particles. The problem may therefore be classed as one in industrial hygiene. The hazard may be largely mitigated by the use of properly designed apparatus. Obviously, the best protection is derived through the use of apparatus which does not require the operator to be subjected to the flying particles nor to a great deal of dust. Sandblast cabinets which are so arranged that the operator directs the sandblast nozzle on the work through apertures in the wall of the cabinet have been successfully used on certain kinds of work. Where the worker is actually exposed to rebounding abrasive material nothing less than a hood or helmet which completely covers the head is suitable.

A form of hood or helmet having a positive air supply is generally recognized as the only suitable form of protector for use inside of sandblasting rooms. Not only is the amount of dust beyond the capacity of the typical respirator to cope with, but mechanical protection is needed for the entire head. The previous edition of this Code recognized a hood

with windows of wire gauze without glass, it being necessary then to wear respirator and goggles inside, but this form is no longer considered satisfactory.

The amount of air to be supplied to the wearer of the protector by an air line is specified as not less than 2 cu ft per min and a lower limit to capacity of the apparatus is set at 6 cu ft. The latter is considered ample for well designed devices. Lung capacities differ and the rate of breathing varies with the effort made by the wearer in performing his task. Surplus air is of no advantage, and the flow may cause discomfort by chilling the head. The proper distribution of the air entering the protector is of importance. Some designs are intended to wash the inner surface of the window with fresh air, or both inner and outer surfaces. In any case the air stream should not be directed against the head. Care must be exercised to see that the air supply is not already contaminated with dust, and the temperature should be controlled for the comfort of the wearer.

A check valve on the air intake hose is sometimes used but is not mandatory. A positive pressure in the supply hose is usually sufficient to prevent any back flow. To regulate the inflow of air a regulating valve is inserted in the air line, and this can be adjusted by the worker to suit his comfort. The short length of hose attached to the protector terminates in a coupling device which can be connected to the air line coming from the compressor, air tank or fan. It is desirable that this coupler be of a type requiring but a 90-degree turn to engage or disengage it, similar in principle to those used on the air-brake connections of railroad cars. The coupler should automatically shut off the air when disconnected, so as to avoid stirring up dust and wasting air. This coupling device enables the worker to leave a blasting room before removing his protector, which is an important consideration. If the helmet were left in the room when not being worn, it would accumulate dust to be later breathed by the wearer.

In some plants using cabinets operated from the outside, the workers are provided with helmets or respirators, since enough dust has been found to leak out to necessitate protection. This is a problem for the individual plant, and it

is not considered necessary to specify the use of protectors in all industrial plants using such apparatus.

114. Man Test.

The final test as to the suitability of a protector is as to whether it actually prevents dust from reaching the worker's lungs. The man test which is here specified is that used by the United States Bureau of Mines in determining the acceptability of an abrasive-blasting helmet. The following description of this test is taken from Schedule 19A of the Bureau of Mines.

Duplicate tests will be made under conditions of typical abrasive-blasting operation. The person wearing the respirator will sandblast the inside surface of a common iron kettle of approximately hemispherical shape, about 30 inches in diameter, and 30-gallon capacity. The kettle will be placed with the plane of the opening inclined 45° from a vertical position and with the lowest point of the rim at about the height of the person's hips. The person will stand at one position in front of the kettle and lean over until the upper part of the body is inclined to parallel the face of the kettle. He will blast the entire inner surface, with the blast at all times directed approximately at right angles to the surface, with the nozzle of the gun about 6 inches from the surface, and with his head approximately 18 inches from the nozzle. He will move his head forward, backward, and sideways during the blasting operation. Further details on the test conditions are:

Kind of abrasive-blasting outfit used: Suction-feed blast; Diameter of air jet: 3/16 inch; Air pressure: 40–70 pounds per square inch; Composition of abrasive to be used: 99+ percent free silica (SiO_2).

Size properties of abrasive: The sand shall be a mixture of 90 percent by weight of essentially no. 1 sand-blast sand and 10 percent air-floated fines. The no. 1 sand shall meet a size specification of not more than 10 percent on a 20-mesh sieve and not more than 10 percent through a 35-mesh sieve; 99+ percent of the fines must be able to pass through a 325-mesh sieve. All size determinations shall be made by standard-mesh sieves.

Length of test period; 30 minutes continuously or in 5-, 10-, or 15-minute intervals with 5-minute periods between these work periods.

Air will be withdrawn continuously during test at the rate of 32 liters (1.13 cubic feet) per minute from the respiratory-inlet covering at a point as near as convenient to the wearer's nostrils. Simultaneously air shall be drawn at the same rate from the source of intake air to the respirator. The particulate matter will be collected from these air streams by electrical precipitation and the collected material will be determined by weight. The amount of particulate matter in the air withdrawn from the respiratory-inlet covering shall not exceed that from the respirator intake air by more than 0.5 mg for the 30-minute test period.

SECTION 12. PROTECTORS FOR EXPOSURE TO IRRESPIRABLE GASES AND VAPORS

This type of exposure sometimes occurs in repairing gas mains and service pipes, cleaning oil tanks and tank cars, working around gas holders, water-gas apparatus, blast furnaces, or coke ovens, repairing leaks in refrigerating systems, in fumigating work, in manufacturing chemicals, and in general where such substances as benzol, carbon bisulfide, ammonia, acid gases, and carbon monoxide are used or are present. Benzol is sometimes used in dye works, rubber factories, lacquer plants, as a vehicle for paint, and other solvent purposes. Carbon bisulfide is used in the extraction of fats and oils, preparation of chlorine compounds, and other chemical work.

121. Hose Masks and Air-Line Respirators.

The hose mask, like the respirator, must fit the facial contour without leaks in order to fulfill its purpose. Like the respirator, it may, or may not, include goggles, depending upon whether the exposure in the specific instance may hazard the eyes. It differs from the gas mask by lacking a filter compartment and filter. Instead of filtering the contaminated air it is provided with a hose line for introducing clean air from an outside source.

Facepieces of soft rubber are considered desirable, but for individuals to whom rubber is objectionable other materials should be provided. For rubber to be durable, it must be able to meet the aging test.

While it is not intended that the air-supply hose should be used as a life line, experience has shown that its use in tanks, mines, and other places sometimes involves a situation where the whole weight of the wearer comes upon the hose, and its rupture, or the tearing off of the harness, might have fatal results. Consequently, a strong harness and hose are specified.

123. Gas Masks.

The gas mask differs from the hose mask in that the breathing tube, instead of being connected to an outside source of clean air, is connected to a canister which chemically filters the inhaled air.

The development of gas masks was carried on intensively during the war, and at its conclusion the results were applied to masks for industrial purposes. Canisters are now available for filtering out any injurious gas likely to be encountered in industrial work, either singly or in combination with others. The use of a mechanical filter in the canister makes this type of protector available for use also in smoke, dust, etc.

(*f*) *Canisters.*

(1) There is already an American standard for identifying the different classes of canister by color. This is subject to extension by the use of color combinations and the use of a stripe of one color upon a base of another color. These colors are mentioned below.

The tests specified for canisters have been developed by the United States Bureau of Mines, and are used by that Bureau as a basis for approval as to permissibility.

(2) For protection in low concentrations of organic vapors, such as alcohol, acetone, aniline, benzene, carbon bisulfide, carbon tetrachloride, chloroform, ether, formaldehyde, gasoline, petroleum distillates, toluol and similar volatile compounds, canisters containing 600 cc or more of activated charcoal are used. These canisters are black in color. Canister gas masks should not be used where the concentrations of the above organic vapors exceed 2 percent, unless tested and approved for higher concentrations.

(3) For protection in limited concentrations of acid gases, such as chlorine, formic acid, hydrogen chloride, hydrogen cyanide, hydrogen sulfide, nitrogen peroxide, phosgene, and sulfur dioxide, canisters containing 600 cc or more of alkaline granules are used. Some activated charcoal is sometimes used in addition to the alkali. These canisters are white in color.

(4) For protection against ammonia gas not exceeding 3 percent, copper sulfate impregnated on granular pumice stone, copper sulfate on charcoal, or silica gel may be used. These canisters are green in color. Copper sulfate has a high capacity for ammonia and will effectively remove the gas from air breathed in concentrations higher than the skin will stand. It is practically useless against other gases.

(5) For protection against carbon monoxide, canisters containing Hopcalite, together with drying agents, are com-

monly used in this country. Hopcalite is a mixture of oxides of manganese and copper, made into granules. It acts catalytically on carbon monoxide in air, causing the monoxide to take up oxygen and change to dioxide. It must be kept perfectly dry as it is of no use when damp. Caustic soda, calcium chloride, and dry activated charcoal separated from each other and from the Hopcalite are used to absorb any moisture in the air passing through the canister. Iodine pentoxide and sulfuric acid may also be used for the purpose. The iodine which is released must then be absorbed in turn. These canisters are blue in color.

(6) For protection against mixtures of the above gases in air, layers of dry activated charcoal, caustic soda fused on pumice stone, fused calcium chloride, Hopcalite, and silica gel, separated from each other by cotton-wool filters and wire screens, are used. These canisters are known as all-purpose canisters and are red in color.

For protection against a combination of organic and acid fumes, canisters containing dry activated charcoal and soda lime are used. These canisters are yellor in color.

For protection against organic and acid fumes and smoke, canisters containing activated charcoal, soda lime, and filter pads are used. These canisters are yellow with a contrasting black stripe.

For protection against ammonia and smoke, canisters containing copper sulfate and charcoal with filter pad are used. These canisters are green with a contrasting black or white stripe.

If a dust filter is combined with a gas filter it is indicated by black or white stripes.

124. Cartridge-Type Chemical-Filter Respirators.

The cartridge-type chemical-filter respirator is suitable for use where concentrations are very low, as in most instances of spray-painting; or where a nontoxic gas or vapor has an objectionable odor or an irritating effect, so that a respirator is desired for reasons of comfort even though not essential for protective purposes. The quantity of absorbent in these cartridges is obviously less than in the standard

canister, and consequently they are not effective for a lengthy period of exposure to the higher concentrations.

SECTION 13. PROTECTORS FOR EXPOSURE TO HEAVY FALLING OBJECTS

The principal need for head protection arises in mining, and falls of rock occasion frequent injuries. According to statistics reported to the Pennsylvania Bureau of Workmen's Compensation, head and face injuries constituted 38.5 percent of all fatal accidents in Pennsylvania coal mines in 1931.

The value of protective headgear for underground workers has been demonstrated by the experience of many mining companies. In 1928 the Susquehanna Collieries Co. had one head injury for every 55,130 tons of coal mined. In October 1929, the company began the gradual adoption of head protection and the number of tons mined per head injury reached 182,723 in 1932. The underground employees at three collieries are now entirely equipped and more than 3,000 hats are in use.

For use in mine drifts, the safety cap must protect against contact with the overhead trolley wire, and hence the material is required to be nonconducting and capable of meeting a test for dielectric strength.

SECTION 14. OPERATING RULES

140. Sterilization.

Protectors which have been previously used should be sterilized before being given to another employee. This will avoid the spreading of infectious diseases. It is desirable to furnish each employee with a protector for his own use, but even in this case they should be sterilized periodically.

Several methods for sterilizing protectors are suggested. The use of an antiseptic gas is perhaps the preferable method, but is not always the most practical because of inadequate facilities, in which case other methods must be used. Boiling water will destroy nearly all germs, but its use should be restricted to those styles of protectors which will not

undergo deterioration when boiling water is used. Examples of material which might deteriorate are certain types of composition lens and leather for side shields.

It is desirable that the work of sterilizing protectors be carried on only under the direction of competent and authorized persons. In many cases the sterilizing agent used may be poisonous, hence its use by uninformed persons should be restricted. The use of phenol is not recommended.

141. Supply and Fitting of Goggles.

Employees are required by rule 10 (*b*) to wear protectors when working in certain classes of operations or processes named in the rule. The mere fact that they are required to wear them will not always assure that this provision is carried out. It is incumbent on the employer so to organize his work that every employee is informed of the places within the works where he can go to obtain new protectors or have adjustments or replacements made. Constant supervision on the part of the foreman and superintendent will insure that full use of these facilities is made by the employees.

142. Replacement of Defective Protectors.

To charge the employer with the responsibility of repairing defective protectors as soon as such defect appears would be an unnecessary burden, as it would require exceedingly close inspection. A more equitable division of responsibility is to require the employee to report broken protectors whereupon the employer should repair or replace them.

143. Inspection of Protectors.

While the responsibility of reporting broken protectors rests with the employee, the question as to what constitutes a broken protector depends on the judgment of the individual employee. Many protectors have been in use so long that the lenses have become pitted so as to interfere with vision, as in the case of oxyacetylene cutting, or the frames have become bent out of shape. These conditions should be corrected by periodical inspections.

The provision of suitable cleaners should be given attention. Each employee need not necessarily be provided with a cloth, but a periodical inspection should be made to see that suitable cleaning material is available in convenient locations.

SECTION 15. TESTS FOR PROTECTORS

150. Scope of Tests.

It is not intended that frames and lenses which are subjected to test will be used in service. Samples must be selected for this purpose. For frames, product of a factory should be fairly uniform, and approval of a model may be considered sufficient by the administrative authority. Lenses are not so uniform in quality, and samples from every large shipment should be tested.

Many of the tests of protective equipment called for by this Code can be made for those not having their own test facilities by the National Bureau of Standards and the United States Bureau of Mines. The National Bureau of Standards is equipped for making both mechanical and optical tests of goggles, and the Bureau of Mines is equipped for making tests of respirators, gas masks, abrasive-blasting helmets, and oxygen breathing apparatus. The Bureau of Mines not only makes such tests for the manufacturers of the protective devices but issues certificates of approval and also issues lists of those devices which have passed the Bureau's test. These matters are all covered by the several publications of the Bureau of Mines, to which reference should be made for further information.

151. Mechanical Tests for Frames of Goggles.

The severe usage and the mechanical shocks to which chippers' goggles are liable to be subjected make it necessary that some assurance be given that the strength of the various parts of the frame is adequate. The flat transverse, the edge transverse, and the joint tests are designed to give some evidence as to the probability of the goggle withstanding the demands of service, so that in the event of the goggle being subjected to a blow, safety will not be decreased. The use of a frame which is too light may result in its becoming

out of shape, thus causing discomfort, which may result in discarding the goggle. Under these conditions, even if worn, it may fail to protect.

It is obvious that if a goggle is to be effective the lens container must at least be strong enough to withstand the tests to which the lenses are subjected. This is the reason for the insertion of the requirement as to strength of lens containers.

As stated above, the test of the joints of the bridge and lens container is designed to give some evidence of the prob-

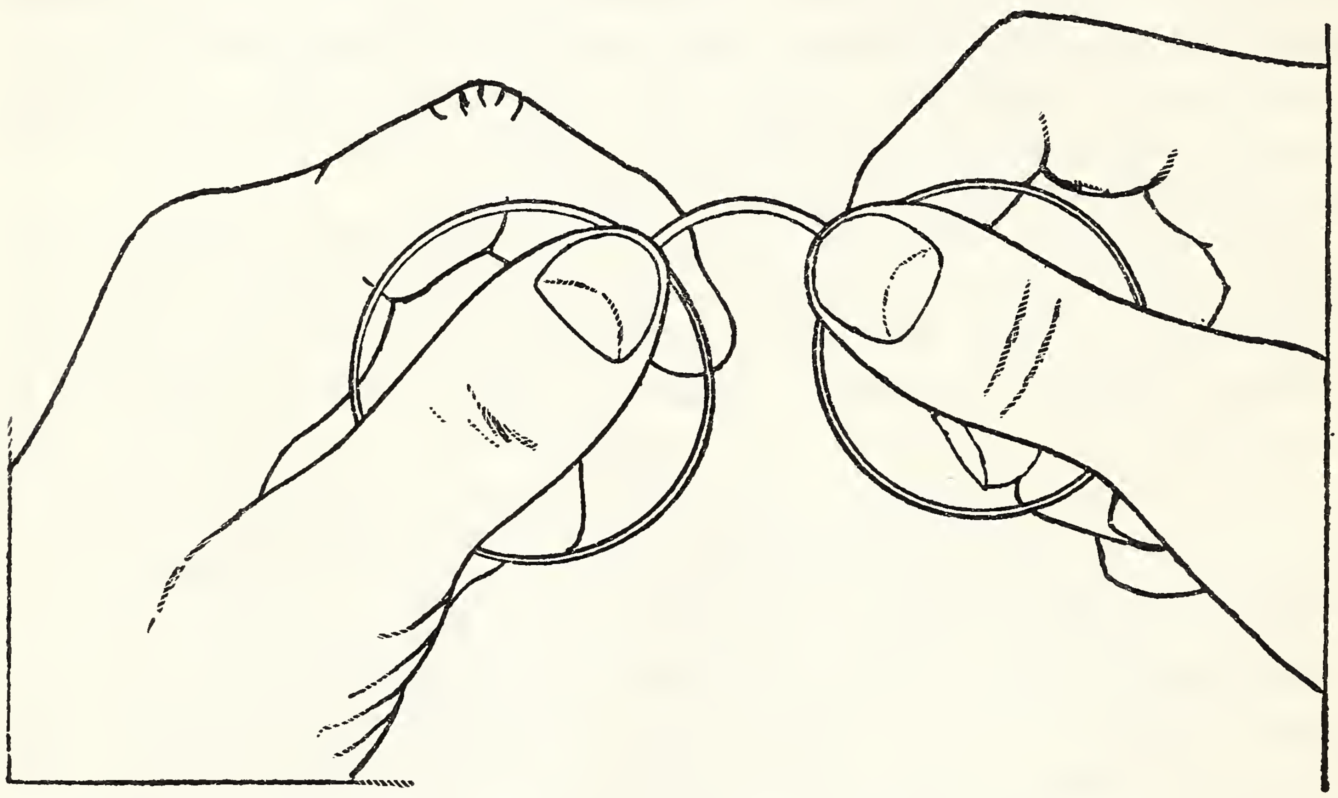

FIGURE 1.—*Method of holding frames of goggles in making tests of joints.*

ability of the goggle withstanding the demands of service. Poor methods used in the assembly of the parts of the goggle will be shown by the presence of jagged ends appearing at the joints after the goggle has been in service some time. This service condition is simulated in the test, and failure is sufficient evidence that the goggle would not stand up under the demands of service.

The test consists merely in bending the frames so that the lenses face each other, and in restoring the goggle to its original shape as nearly as possible. This test subjects the

joints to a stress which in poorly constructed goggles will be great enough to cause the bridge to separate from the container. Figures 1 and 2 show the method of holding the lenses during conduct of the test, and the appearance of the frame after bending.

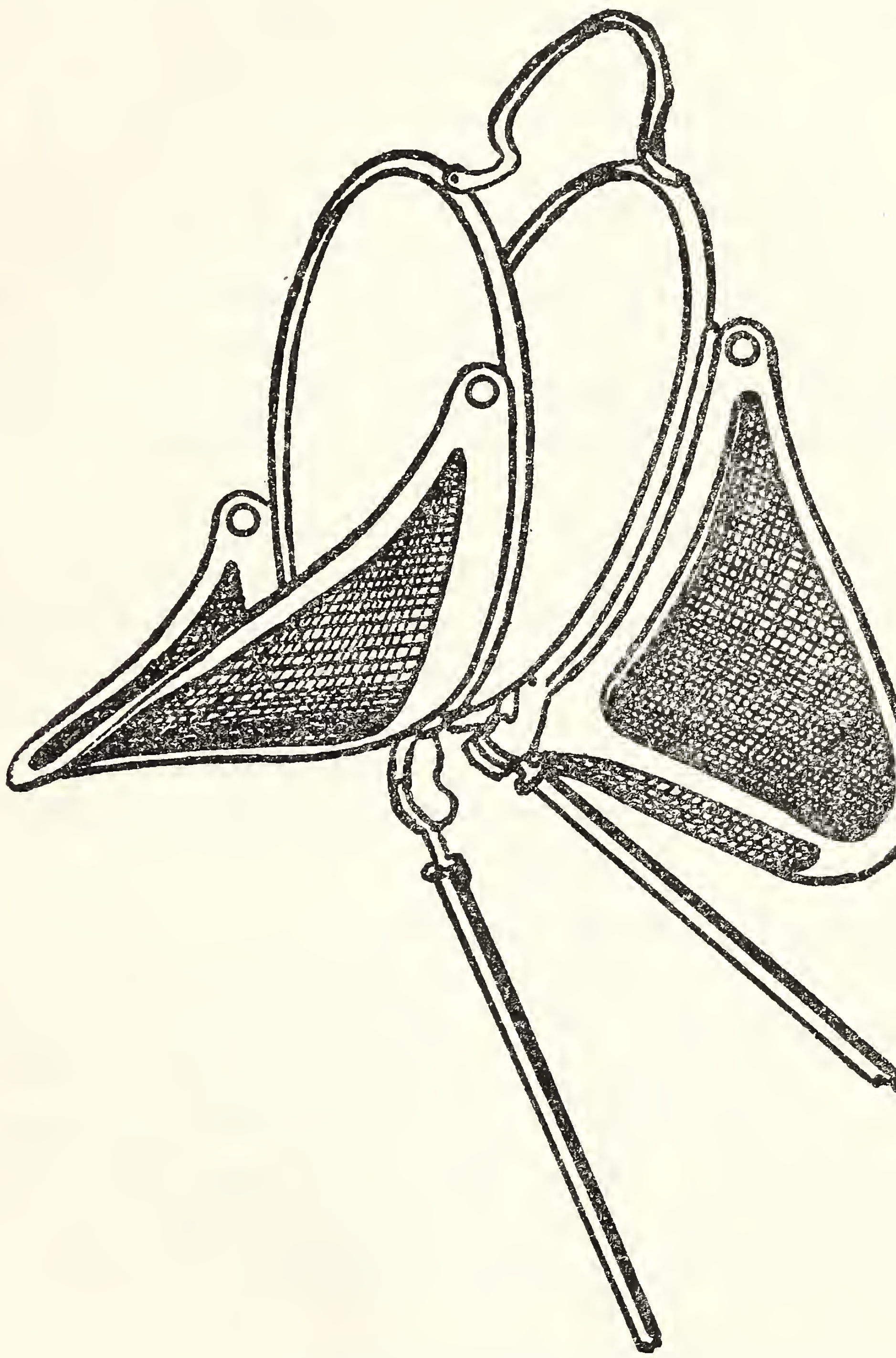

FIGURE 2.—*Appearance of frame after bending.*

152. Test for Corrosion.

The test for corrosion as outlined in this rule is designed to show the ability of metals to resist the corrosive action of such chemicals as sodium chloride and sulphur dioxide

which are encountered in industrial operations. This is an effective test, but is not necessarily the only one which can be used. For the sake of uniformity it is desirable to use the test specified in order that test results from separate sources may be compared.

It has been found by observation that the use of a boiling solution allows the liquid to penetrate farther into the outer surface of the material, because of the action of the heat expanding the metal and opening the pores, than is the case if a cold solution is used. In order to retain the salt in the pores it is necessary to bring the metal to room temperature. This should be done by cooling in a solution of the same salt (sodium chloride) in order that contact between the solution and the metal be not lost by the flaking off of the crystals which would form if the frames were allowed to dry in the open air.

The frames should not be wiped off after removal from the solution because this would remove not only the liquid but also all evidence of corrosion. A careful rinsing after the frames have dried a sufficiently long time to allow of chemical action between the salt and the metal, if any, will remove the adhering salt but will not remove the corroded particles or flakes. The presence of these particles shows that corrosion has taken place.

153. Mechanical Tests for Lenses.

Lenses for goggles used by chippers are liable to be subjected to severe blows. Hence in order to determine whether the quality of the lenses is such as to withstand the service, it is necessary to devise tests to which representative samples may be subjected. These tests are described in this rule and are based on the results of an investigation of samples of a number of manufacturers bought in the open market. They conform closely to tests which have been used by a number of large purchasers of goggles.

There are two types of lenses in general use for goggles used by chippers, namely, (1) lenses made of a single piece of glass, and (2) lenses constructed of two glass disks held together by a suitable binder. The protective qualities of the two types are based on entirely different principles. Lenses of the first type depend on the strength of the glass

and upon the method of mounting. The lenses are made of glass of such quality and so mounted that a severe blow may be received without fracture. There is no protection, of course, from the extremely severe blows which would drive the glass out of the frame and into the eye. However, for such a case, the wearing of goggles neither mitigates nor increases the hazard.

In the case of the two-element lens, a severe blow is expected to crack the lens, but the construction is such that the glass will adhere to the binder and the particles do not impinge on the eye. The construction of the lens container in both cases should be such that the lens will fail before the container is deformed.

Since the criterion upon which the protective quality is based in each case is the ability of the lens to withstand a blow without splinters of glass leaving the lens on the eye side, it is apparent that the test should include this as a basis for acceptance or rejection. In general, test (1) may be said to be a test for solid glass lenses and test (2) for laminated lenses, but compliance with test (2) on the part of one-piece lenses is satisfactory.

The manner of supporting the lens during the drop test is important, and in order to obtain consistent results, both in a plant where testing is conducted at regular intervals and by manufacturers of goggles, a uniform method should be adopted. The lens should be mounted on a rubber washer supported in the manner specified in the text of this rule.

Federal Specification HH–G–156 requires 80 percent of rubber in the compound used for a grade *A* gasket; requires a tensile strength of 2,200 lb per sq in., and an ultimate elongation of 2 to 12 in. The permanent set after 10 minutes of rest must not exceed 20 percent. For methods of making the tests of rubber, reference may be made to Federal Specification ZZ–R–601.

Since the previous edition of this code was issued, there have been placed on the market lenses which will withstand a much more severe test than is here prescribed. Some purchasers are requiring compliance with more severe tests. It is thought, however, that these tests are sufficient and assure satisfactory lenses. Additional strength is obtained

by heat-treating the glass. The essential difference between "heat-treated" or "case-hardened" lenses and ordinary annealed lenses is that the surfaces of the former are under compression and the interior is in a state of tension. This condition is produced by heating the glass to an appropriately high temperature, and then cooling the glass rapidly.

154. Optical Tests for Lenses.

The pathologic effect of ultraviolet radiant energy upon the animal tissues has long been recognized, but it is only in recent years that detailed studies have identified the harmful rays and their specific action. The skin as well as the eye is affected by ultraviolet radiant energy, especially when the intensity is high. The action is similar to sunburn. In such processes as arc welding, protection to the skin as well as the eyes is necessary. Excessive brightness must also be avoided. Still another possible cause of impairment of vision might arise through the absorption of an excessive amount of heat energy by tissues and humors of the eye, but there is no direct evidence that the eye is more subject to injury in this way than any other part of the body. It has been claimed that cataract is caused by the infrared radiation just beyond the visible spectrum (see Ill. Eng. Soc. Trans., vol. 24, p. 144; 1929) and whether this claim is admitted or not, protection against such radiation is so easy of accomplishment that it seems desirable to provide it.

Glassblower's cataract is attributed, by Dr. J. H. Clark (Am. J. Physiol., vol. 113, p. 538; 1935), to the effect of ultraviolet light followed by excessive temperature in the presence of an excess of calcium salts.

In order to provide complete protection it is necessary to limit the radiant energy in the ultraviolet to a negligible quantity; the brightness of the source must be reduced to such a degree that no discomfort will ensue if work is carried on continuously; the radiant energy in the infrared should be reduced so that it will not be unnecessarily large.

In order to be assured that adequate protection is provided it becomes necessary to know the optical properties of the glass used for lenses and windows. This is done by subjecting the glass to definite tests which, however, require

special apparatus, the manipulation of which should be attempted only by experts.

Before proceeding with a discussion of the detailed tests it appears desirable to give a discussion of the method of making the tests in order that their application and limitations will be understood.

Most sources of light emit mixed radiation. That is to say, light waves of a variety of wave lengths are present in radiant energy. This is true whether it comes from a body of molten metal, from a lamp filament or flame, or from the sun. The eye is unable to analyze such light and determine its components. In this respect the eye differs vastly from the ear, which can analyze a chord and perceive the individual elements or tones. The eye has no such power of analysis and gets only an impression due to the combination of wave lengths or colors of light which may be present. Moreover, the eye is very limited in the range of its perception, most of the radiation from the usual sources containing a majority of waves or rays which are not visible to the eye, since they lie outside of the range in which the eye is sensitive to light.

Light can be analyzed in a number of ways, the most familiar being by its passage through a prism of glass. This separates the waves of different wave lengths into a spectrum in which the different wave lengths appear as different colors. The visible spectrum ranges from the red to the violet. The waves outside of this range are designated as the infrared on the one hand and the ultraviolet on the other.

When the light of different wave lengths is mixed together, the eye sums up the effect of the visible portion. Measurements of the intensity of the visible are made by means of the photometer, in which this intensity is compared by the eye with the intensity of the light from a standard source. For the portion of the radiant energy which is not visible other means must be used. Since when light is absorbed its energy may be entirely converted into heat, one of the most simple methods of measuring radiant energy, whether visible or not visible, is by means of a thermopile, where the absorbed light produces heat and this heat in turn produces a measurable electric current. The thermopile can be used to measure

the total energy, or, if the radiation is analyzed into a spectrum, the energy of each particular wave length can be measured independently.

No glass transmits all of the light which is incident upon it, but some is always absorbed and some is reflected from its surface. Ordinary clear glass transmits a high percentage of the visible, but does not transmit either the very long waves or the very short waves. When glass appears colored it is due to the fact that it does not transmit all of the visible rays but some of them are stopped by it. The transmission of glass is usually expressed as a percentage which gives the ratio of the amount of light transmitted to the amount which is incident upon it. This transmission is sometimes expressed in terms of the entire visible spectrum, sometimes in terms of a particular wave length which must of course be stated, and sometimes in terms of the entire radiant energy. It is measured by letting the light from a definite source fall upon the thermopile mentioned above and then interposing the glass whose transmission is desired. The ratio of the two deflections obtained will give the transmission.

The measurement can be carried out with any portion of the radiant energy from the source that may be desired. Thus one may use the total or one may spread the light out into the spectrum by the use of the prism and let only a single wave length or color fall upon the thermopile. Full details of the methods of making such measurements will be found in Technologic Paper of the Bureau T119, entitled "The Ultra-Violet and Visible Transmission of Eye-Protective Glasses," and in Scientific Paper S325, entitled "Spectroradiometric Investigation of the Transmission of Various Substances." Much of the information in the latter is also given in Technologic Paper T93, entitled "Glasses for Protecting Eyes from Injurious Radiation."

When the transmission for a particular wave length is measured it is almost immaterial what source of light is used, provided it can be kept constant during the measurement. Since the transmission for the total radiant energy is dependent upon the transmission for each particular wave length, and since the amount of energy which gets through will depend upon the amount of each particular wave length emitted

by the source, it is evident that the result will depend upon the composition of the energy received from the source. It is consequently necessary when considering total transmission to have a definite and reproducible source of radiant energy. The value of transmission measured will depend upon the spectral distribution of the energy from the source. Consequently a source which is especially strong in light of one color and weak in light of another color will not be suitable. An example of such a source is a mercury-vapor lamp. A source of suitable spectral distribution would be the sun or some artificial source having a somewhat similar distribution and sufficiently reproducible.

For the tests here specified a source of light which is sufficiently reproducible and which is easily obtainable has been stipulated. This source is an ordinary incandescent lamp operated under specified conditions. The spectral distribution of the light from such a source changes somewhat when its operating temperature is changed. But this change is a gradual one, and slight changes in the operating temperature of a filament are not important. In order to make the source sufficiently definite it has been specified that it shall be operated at such a voltage as to emit 18 lumens per watt, which corresponds to the commercial rating of the 200-w lamp. This commercial rating may, of course, be changed from time to time, but such change is not likely to alter the conditions sufficiently to make it necessary for it to be taken into account in testing lenses for compliance with these specifications.

If it is found that a lamp is operating at a slightly different specific consumption (lumens per watt) at its rated voltage, correction may be made by operating at a slightly different voltage. Within a small range the change in lumens per watt amounts to 0.3 for 1 v. Accuracy of adjustment is not important, as values of transmission are only slightly altered by large changes in operating voltage.

It is well to point out that such an artificial source is preferable to sunlight for several reasons. In the first place it is more convenient for use in the laboratory and is independent of the weather. In the second place, sunlight is not so definite, as it varies with the condition of the atmosphere, and with the altitude of the sun in the sky. The latter

varies not only from hour to hour during the day, but also with the season of the year.

The specifications have been chosen so as to make the necessary tests as simple as possible. It has already been explained that the two principal purposes of optical specifications are to limit the visible and the ultraviolet light. We will consider first the ultraviolet.

The wave lengths 313, 334, 365, and 405 millicroms represent intense lines in the spectrum of light from a mercury-vapor lamp. This lamp is suitable for measurements of transmission at individual wave lengths, although as pointed out above, it is not suited for measurements of total transmission. This source is especially rich in ultraviolet light and is useful on that account for carrying out a test of transmission in the ultraviolet region.

The spectrum line 405 millimicrons is visible to the eye and consequently a measurement at this wave length can be carried out with the more usual optical apparatus. For the shorter wave lengths, photographic methods must be resorted to or else the measurements carried out by means of some such instrument as the thermopile already referred to.

The specification has been written with the assumption that the quartz-tube mercury-vapor lamp will be used in tests as the source of light and that it is sufficient to make measurements at the four specified wave lengths representing lines in the mercury spectrum. This would not be permissible if commercial glasses had narrow transmission bands occurring at points between those at which the measurements are made. Experience shows, however, that no difficulty may be anticipated on this score. Measurements of a large variety of glasses show that the ultraviolet transmission is of two main types. In one type in which many blue and purple glasses are included, the transmission increases rapidly to a maximum at 320 to 380 millimicrons, as the wave length is shortened below 405 millimicrons. In the other type, to which the deep orange and brown glasses belong, the transmission decreases rapidly with wave length. Any glass of average thickness (2 mm) which would be used for eye protection is opaque to radiation of wave lengths less than about 290 millimicrons. Hence the question of testing protective

properties of glasses against radiations of wave lengths less than 280 millimicrons need not be considered.

From the above it is evident that measurements at the wave lengths specified in the rule will be sufficient to insure that the intensity transmitted at any point in the ultraviolet region of the spectrum is too small to be injurious. For group *F* it is sufficient that this value be less than 1 percent at lines 313 and 365. For groups *G* and *H*, where more intense sources are concerned, the transmission is further restricted at these wave lengths and is also restricted at 405 millimicrons.

It has not been attempted to limit the transmission of visible light to the definite amounts which will be proper in different processes and occupations, since the wearer of the goggles can decide very easily what is suitable for a particular purpose. No visible light which is comfortable to the observer will injure the eye. Consequently, only rough and rather high limits have been set for the transmission of visible light.

To protect from glare, the light must be cut down at least one-half. But still lower transmission will frequently be desirable.

For processes included in groups *G* and *H*, such as oxy-acetylene welding and electric-arc welding, the shade number chosen sets a limit to both the visible and the infrared energy. The processes included in this group will require among themselves quite different reduction in the intensity of the visible light. The reduction must be much greater in acetylene welding than in much furnace work. The comfort of the wearer is a sufficient criterion for this purpose.

Electric-resistance welding differs very much in the conditions presented in different cases. Where the incandescent metal is almost entirely screened from the worker's eye by the apparatus or by the material itself, protection is optional with the worker. Where the intensely hot metal is exposed, the conditions are much the same as for furnace work and similar protection is prescribed. The intensity of light differs greatly in different cases and a suitable shade number must be chosen.

The following suggestions, taken from the Federal Specifications for Welders' Goggles and Welders' Helmets, may be helpful in choosing the particular density of glass which is appropriate for the particular operation, but a final decision in this matter can best be made by the person who is wearing the goggles or helmets, since the principal consideration is to diminish the intensity of the visible light to the point where there will be no glare but where the object being welded can be distinctly seen.

Shades Nos. 3 and 4 filter lenses are intended for glare of reflected sunlight from snow, water, roadbeds, roofs, sand, etc., for stray light from nearby cutting and welding operations, and for metal pouring and furnace work.

Shade No. 5 filter lenses are intended for light gas cutting and welding, and for light electric spot welding.

Shade No. 6 filter lenses are intended for gas cutting, medium gas welding, and for arc welding up to 30 amp.

Shade No. 8 filter glasses are intended for heavy gas welding, and for arc cutting and welding exceeding 30 but not exceeding 75 amps.

Shade No. 10 filter lenses are intended for arc welding and cutting exceeding 75 but not exceeding 200 amps.

Shade No. 12 filter glasses are intended for arc welding and cutting exceeding 200 but not exceeding 400 amps.

Shade No. 14 filter glasses are intended for arc welding and cutting exceeding 400 amp.

155. Tests for Mechanical-Filter Respirators.

(*a*) *Resistance to Air-Flow.*—The method of test here specified is that used by the United States Bureau of Mines in passing upon the suitability of respirators. An air stream is drawn through the respirator by a suction pump at a measured rate, and a manometer tube shows the difference between atmospheric pressure and that in the tube connecting the respirator with the pump. The Technical Paper 394 referred to is entitled "Dust Respirators: Their Construction and Filtering Efficiency", by Katz, Smith, and Meiter.

The requirements here may be regarded as severe, but they can be met by good design, and there seems to be no

good reason why this standard of excellence should not be attained.

(*b*) *Filter for Siliceous Dusts.*—The requirement for filtering efficiency is also high, but not beyond commercial attainment. Silica dust is chosen for testing purposes because it is one of the important dusts to be protected against, it is easily obtained in the necessary degree of fineness and purity, and results with it are reproducible. Different methods of determining the amount of dust passing through the filter are recognized as satisfactory.

The impinger apparatus consists essentially of a sampling device comprising a container and the impinger tube, connected to a source of suction for drawing in the air to be sampled. The impinger tube is a glass tube tapering to a small opening at one end. In front of this opening and normal to it, a glass plate is attached at the proper distance, or the tube is pushed through the rubber stopper holding it so that the tip remains at the proper distance from the bottom of the flask. In either case, the tip of the tube is immersed to a definite depth in liquid, usually distilled water or mixtures of distilled water and alcohol, although other liquids are used occasionally. The suction apparatus can be driven by an electric motor, by compressed air, or by hand. A measured quantity of air, usually 10 to 30 cu ft, is drawn at a rate of about 1 cu ft per min through the impinger, which traps the dust particles in the liquid. A measured fraction of the liquid is mounted in a cell in the field of a microscope, and the particles of dust are counted.

Recently a midget impinger, sampling at 3 to 5 liters per min, has been suggested by the United States Bureau of Mines. The advantage of the smaller unit is that it is much less bulky and therefore better adapted to field use.

The later modifications in the use of this method are given by Hatch (J. Ind. Hygiene, vol. 14, p. 301).

An electric precipitator tube for sampling finely dispersed fumes, such as lead and zinc oxide in air or other gases, consists of a Pyrex or quartz tube, about 2.5 cm diameter with a side-arm outlet. A stiff metal wire is supported centrally down the tube to within about 2 cm of the bottom

end, which is open. Around the tube is wrapped a sheet of metal foil or fine wire netting. The foil and central wire are then connected to the high-tension terminals of a transformer, preferably of 15,000 to 25,000 v, 60 c/s. The dusty air is then drawn through the tube at a rate of 15 to 40 liters per min, and the dust is deposited inside the tube, with small amounts on the central electrode. The collected dust is then weighed, determined chemically, or counted.

A Tyndallmeter is an optical apparatus which utilizes the property of the dust particles, held in suspension in air or liquid, of reflecting some of the light in an incident beam at right angles to its original course. The reflected light is measured in a photometer or illuminometer, and the photometer reading is varied by diluting the dust-laden air (or liquid) with uncontaminated air (or liquid) until the reading is the same as for air which has passed through the respirator. The percentage of clean air in the mixture is then equal to the percentage of dust which has been intercepted by the respirator. The method is applied here to liquid samples from the impinger. Actual quantities of dust can be measured by this method on the assumption that the amount of reflected light is proportional to the number of dust particles in the air, and calibrating the apparatus by comparison with the impinger method. The calibration will not hold good for particles of different size, color, or other property affecting reflection.

The choice of 5.2 hr for the duration of this test was based on the fact that in an 8-hr working day an average man doing moderate work will breathe about 10 cu m of air, the same amount of air as passed through the respirator in this test. The average rate of breathing is about ¾ cu ft per min.

156. Tests for Rubber.

For rubber to retain the qualities which make it flexible and otherwise suitable for the purpose, it must be of good grade. Durability depends upon retention of these properties. A physical test combined with an aging test is a better criterion of the desired quality than any specification of chemical composition. The test may also be carried out more quickly.

157. Tests for Hose Masks, Air-Line Respirators, and Abrasive-Blasting Equipment.

(*a*) *Hose for Hose Masks.*—These tests are the same as have been used by the United States Bureau of Mines for some years in determining approvals of apparatus, and are now recognized standards.

158. Tests for Gas Masks and Canisters.

These tests have been used by the United States Bureau of Mines for a number of years, and are the basis for approvals for use under the specified conditions. They are generally recognized standards in this field.

WASHINGTON, June 29, 1938.

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[References are to section numbers (where preceded by "Sec.") and to rule numbers and the discussion of the rules. For example, "13" refers both to rule 13 (p. 5) and to the discussion of rule 13, on page 54.]

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